Grid Interfaced Solar Water Pump Using SRM with Incremental Conductance Technique

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Abstract:

The goal of this study is to create a grid-connected solar water pumping system with a single stage that uses a switching reluctance motor and a PV control system. Photovoltaic systems are important as environmentally friendly energy sources because of their feasibility, which has its own precedence, but there are some concerns to consider. As a result, the need to develop high-efficiency photovoltaic power generation remains a pressing issue. The most practical and effective technique to overcome the problem is to automatically track the sun. PV module performance is determined by solar radiation and air temperature, which have an impact on power characteristics, voltage and current. As a result, a controller is required to reduce the impact and make the most of the PV array's electricity. Different tracking systems are used, and the current framework for using solar panels to pump water has attracted a lot of attention. The utility grid is used with a switching reluctance motor in the current topic. SRM has a significant advantage over alternative motors. Systems connected to the grid are becoming more popular due to their reliability, accuracy, and endurance. Since solar technology has advanced significantly, MATLAB simulation was used to develop a simple control system and design for a PV electrified switching reluctance motor for pumping applications.

Keywords: Maximum Power Point Tracking (MPPT), voltage source converter, Photovoltaic array, switched reluctance motor (SRM), Mid-point converter, bidirectional power flow.

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1. Introduction

The Water is a basic requirement for everyone. Pumping water in areas with erratic water supplies necessitates the use of water pumps. The PV-activated pumping system is depicted in Figures [1]. The current motivation is to develop a well structure with a continuous pumping system [2]. To configure the standalone systems, numerous paths are followed [3]. The irregular nature of PV power prevents such systems from continuously dispensing a wide range of water, even if they are coherent and acceptable. Coupling a battery [4] is one method of resolving this problem and obtaining constant and exhaustive amounts of water to impart. However, those patterns are not supported in real time because using a battery is more expensive and necessitates uniform sustenance. Battery life diminishes, necessitating the use of protective supplies [5].

In a murky and gloomy environment, the most organized grid system distributes water of sufficient capacity without repeat failure or power outage. [6]. They are simple to set up and can be used in any treetop. When PV is insufficient to meet the load demand, the grid dispatches a supplement voltage current product. Furthermore, there is no need to pump water; instead, the grid is used as a cache segment, and the entire generated power is distributed across the grid by maintaining resolution in input and output.

The mentioned configurations are said to provide continuous power to the motor-pump setup, allowing for continuous H2O supply. However, practically all systems principally consist of a double stage with unidirectional power flow [6]. The corresponding arrangement suffers from significant losses, control convolution, and an inability to reduce harmonics and oscillations. A bidirectional converter with transformer is available in some systems. Because of the noisy behaviour of the isolated transformer, it may become unreliable and inefficient. One of the major drawbacks of previous systems is their inability to drive agitation and inappropriate maximum tracking, which forces them to be ineffective. Losses caused by the step-up model and a capacitor with a DC link make solar that steers the sump impracticable [7]. There are various problems in the different typologies that use multiple step conversions to hilt entire point should emerge. Due to its lagging nature, the Switched Reluctance motor is owned [8]. Cost effectiveness, high efficiency, and the need for a straightforward converter are among the aids.

2. PRINCIPLE AND OPERATION OF SYSTEM

The photovoltaic principle governs solar water pumps, which use solar panels to convert light energy into electrical energy and then use a midpoint converter and SRM motor to power a water pump. They can be used for a variety of purposes, but the primary one is irrigation [10]. Voltage source rectifiers, from which enhanced generalized integrated gate pulses are generated, and 230V and 50Hz single-phase and three-phase grids are coupled with a voltage controller to current controller, from which pulses are formed. The output is fed into the mid-point converter. A PI controller receives inputs of voltage and current from the mppt algorithm for error removal before being added to a saw tooth carrier, and hall signals collected by sensing hall signals from the motor were used to achieve mid-point gating. As can be seen in fig.2.1, AND logic is provided for both the commutation controller's hall and carrier signals. The fundamental principle of the system is to maintain a consistent pace under various conditions.

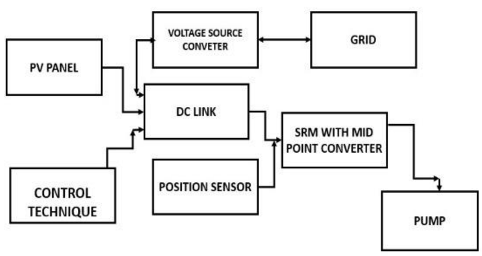

Figure 2.1 Block Diagram.

3. WORKING MODES

Operating methods based on system consumption are divided into four types, as shown in Fig.3.1.

Mode 1: The panel provides power to the motor. As a result, the grid is hardly unusable and lies dormant.

Mode 2: As grid suckles fluctuation through VSC, lower irradiance and pump demand haven't abut.

Mode 3: Power is zero when it comes to night-time behaviour. The grid provides all of the power.

Mode4: This refers to situations where total solar power is used to feed the grid.

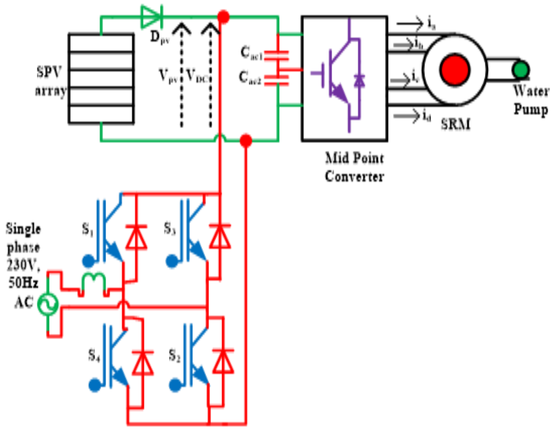

Figure 3.1 Operating modes

4. CONFIGURATION OF THE SYSTEM

Solar Panel, SRM motor, and Midpoint Converter are the primary components configured by the system.

4.1. Solar panel

Sun panels convert solar energy into electricity. The array depicted in fig.4.1 is produced by joining the cells in series and parallel to form a module. Excitation of energy occurs when the sun's rays fall on the panel [2]. The designing panel is one of the important.

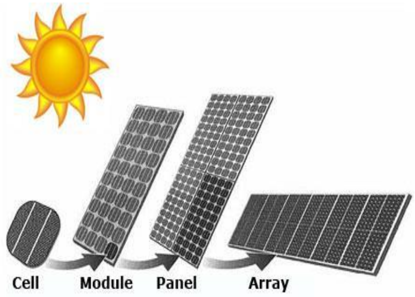

Figure 4.1. Solar Array

4.2. Mid-Point Converter

Inverters that convert dc to ac power are known as mid-point converters [9]. It consists of two four
switch units separated by an inductor that acts as an interfacing unit. The Switched Reluctance Motor is driven by this. They also have a diode, which protects the circuit by preventing leakage currents.

4.3. SR Motor

Stator windings, a rotor with an iron core, and a single-excited reluctance motor with double saliency. In comparison to the stator poles seen in fig.4.2, the rotor has fewer poles. Motor runs based on reluctance torque [4]. The electric design is complicated due to the necessity of switching, whereas the mechanical design is simple due to the absence of not powered moving parts.

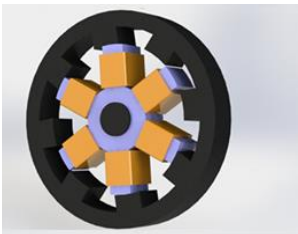

Figure 4.2 SR Motor

5. CONTROL SCHEME

When the grid is present or not, a control strategy is used to achieve smooth MPPT tracking and structured working. For maximum power control, grid voltage inclusion is extracted by the network. The volatility in power or disturbance at the grid side is superintendence by dynamic smoothing of the VSC on the grid.

5.1 MPPT Technique

By measuring small changes in PV array voltage and current, the controller forecasts the effect of a voltage change using the incremental conductance method. The perturb and observe (P&O) method is slower at tracking changing conditions than this method, despite requiring more computation in the controller

```
function d = fcn(v,v1,i,i1,d1)
%#eml
dd=0.001;
dv=v-v1;
di=i-i1;
x=i+(v*di/dv);
y=di/dv;
z=-i/v;
if x==0
   d=d1;
else if y>z
       d=d1+dd;
   else d=d1-dd;
   end
end
```

Figure 5.1 Incremental Conductance Algorithm

5.2 Grid and Voltage Source Converter

Six switches (S1-S6) make up a voltage source converter. To remedy, diverse pulses ought to be provided, as shown in fig 5.2. An upgraded GI controller with a gain and a PI controller takes the grid voltage as its input. In addition, a direct current link is provided as an input, which filters out faults [9]. Both of these are combined, and the product is applied in order to generate pulses, proportional integral is applied to pulse width modulation.

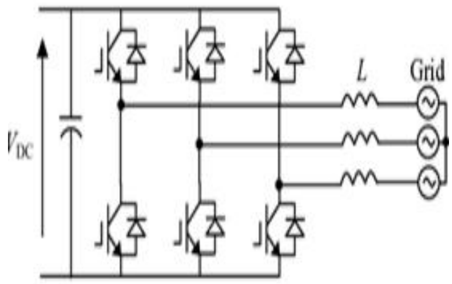

Figure 5.2.VSC

5.3 Switched Reluctance Motor

High currents travel through the winding when the motor is started, causing damage to the motor. To overcome this problem, the midway convertor is regulated in fig 5.3 with the windings, resulting in a continuous water supply [8]. The duty cycle generated by the voltage controller is compared to the hall signals collected from the motor.

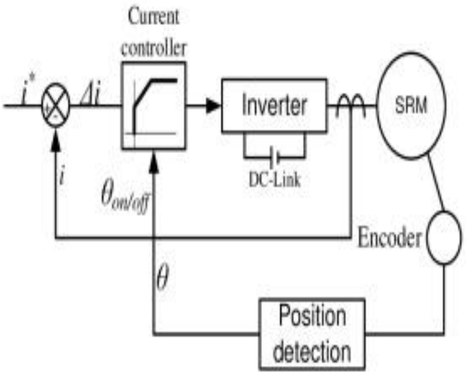

Figure 5.3. Position Sensing

6. RESULTS AND ANALYSIS

MATLAB is used to replicate a lot of the present design in order to determine whether all of the possible conditions are suitable. Under voltage disruption, simulation is analyzed and investigated.

- **Change In Insolation Levels**

Execution when PV is available and unavailable and the insolation changes, as shown in fig. 6.1 From daylight to evening, the irradiance decreases from 1000w/m2 to 200w/m2 before dropping to zero at night.

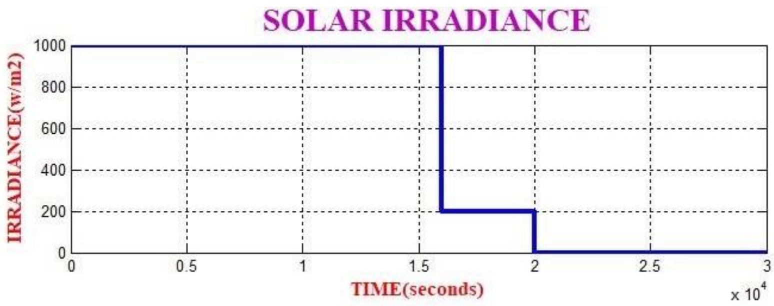

Figure 6. 1 Irradiances Levels

- **Pv Power and Voltage**

In figs. 6.2 and 6.3, we are able to observe a smooth MPPT track that shows the sun moving from east to west and that the sun emits different amounts of radiation in the morning, afternoon, and evening. However, the tracking is carried out appropriately.

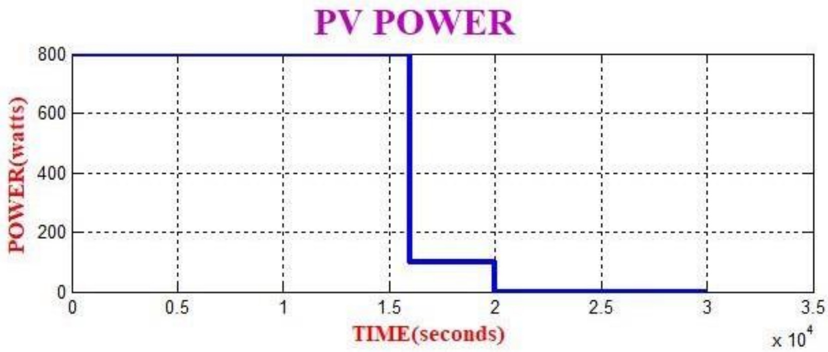

Figure 6.2. Power of PV

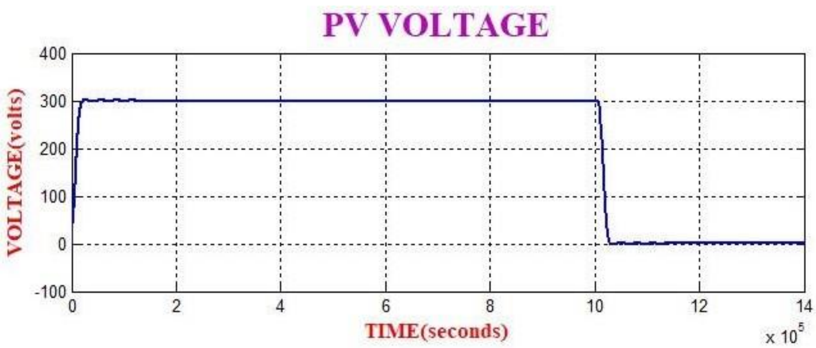

Figure 6.3. PV voltage

- **Grid Voltage**

Even when the sun isn't shining, the voltage remains constant. The sinusoidal wave of 230v is depicted in the graphs as shown in fig.6.4. The solar-powered panel motor sends voltage to the grid during the day, and the grid is active during the moon because the motor is driven by the grid.

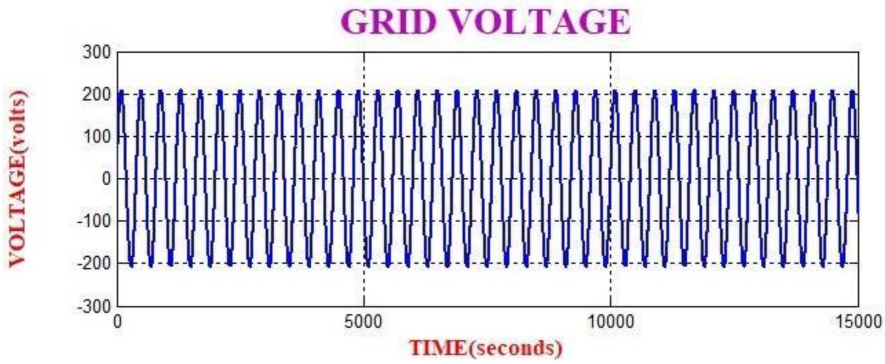

Figure 6.4 Grid Voltage

- **Motor Speed**

In the morning and at night, the motor is powered by two sources: solar and grid. The essential goal, however, is to ensure that the motor and pump systems have a continuous supply during the day. As a result, a consistent supply is established, as seen in fig 6.5

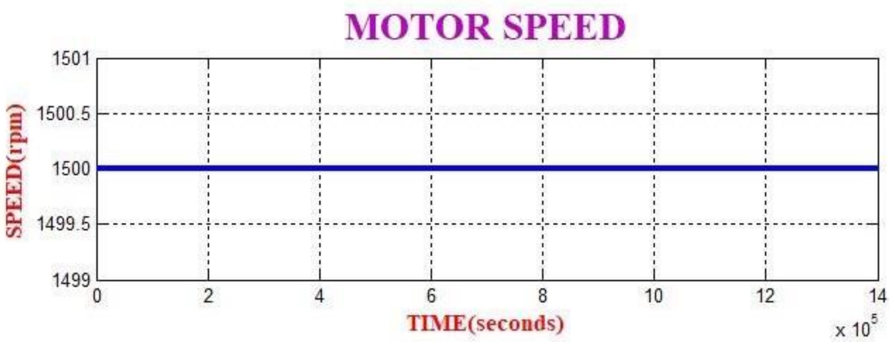

Figure 6.5. Motor Speed

- **Suppression of Harmonies**

Because of the use of a single stage system, a boost converter has not been used to eliminate harmonic generation, as shown in fig 6.6.

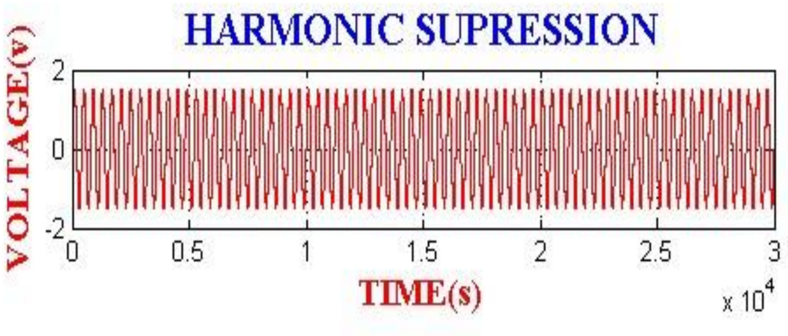

Figure 6.6. Harmonic Suppression

- **DC Link Voltage**

The Voltage varies as change in solar irradiances varies as seen in fig.6.7

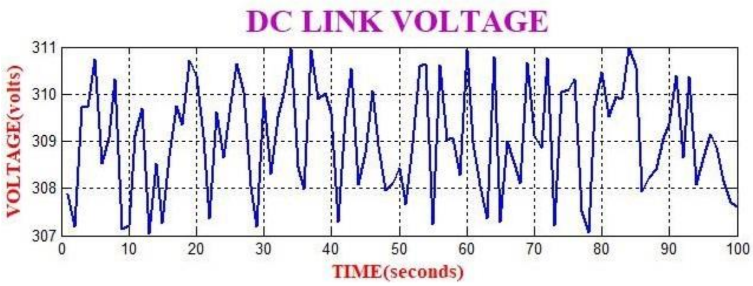

Figure 6.7.Dc Link Voltage

7. CONCLUSION

A structured, well-organized, and attested device advanced arrangement has been offered. Advanced methods for overcoming stumbling blocks are being developed. The system's effectiveness has been increased by utilizing SRM at the fundamental frequency while utilizing a voltage source converter to track maximum power.

In simulation, the SRM sprints at a speed of 1500rpm. Modeled closed loop control that maintains stability and continuous water steering without interruption. Smooth mppt tracking is provided by the P&O algorithm. MATLAB is used to simulate the outcomes. The title was justified based on the findings.

References

1. H. Parveen, U. Sharma and B. Singh, "Standalone PV-BES Based Synchronous Reluctance Motor Drive for Water Pump," 2021 International Conference on Sustainable Energy and Future Electric Transportation (SEFET), Hyderabad, India, 2021, pp. 1-6, March.2021.
2. J. V. M. Caracas, G. d. C. Farias, L. F. M. Teixeira and L. A. d. S. Ribeiro, "Implementation of a High-Efficiency, High-Lifetime, and Low-Cost Converter for an Autonomous Photovoltaic Water Pumping System," *IEEE Transactions on Industry Applications*, vol. 50, no. 1, pp. 631-641, Jan.-Feb. 2014.
3. S. Meunier et al., "Sensitivity Analysis of Photovoltaic Pumping Systems for Domestic Water Supply," in IEEE Transactions on Industry Applications, vol. 56, no. 6, pp. 6734-6743, Nov.-Dec. 2020.
4. R. Rai and B. Singh, "Power Management of Islanded Solar PV-Battery System for Submersible Pump Induction Motor and Local Loads," 2022 IEEE IAS Global Conference on Emerging Technologies (GlobConET), Arad, Romania, 2022.
5. M. Kashif, S. Murshid and B. Singh, "Adaptive Hybrid Generalized Integrator Based SMO for Solar PV Array Fed Encoderless PMSM Driven Water Pump," in IEEE Transactions on Sustainable Energy, vol. 12, no. 3, pp. 1651-1661, July 2021.
6. S. Shukla and B. Singh, "Reduced-Sensor-Based PV Array-Fed Direct Torque Control Induction Motor Drive for Water Pumping," in *IEEE Transactions on Power Electronics*, vol. 34, no. 6, pp. 5400-5415, June 2019.
7. J. V. M. Caracas, G. d. C. Farias, L. F. M. Teixeira and L. A. d. S. Ribeiro, "Implementation of a High-Efficiency, High-Lifetime, and Low-Cost Converter for an Autonomous Photovoltaic Water Pumping System," in *IEEE Transactions on Industry Applications*, vol. 50, no. 1, pp. 631-641, Jan.-Feb. 2014.
8. A. Yalavarthi and B. Singh, "An Adaptive-Gain Super-Twisting Position Observer for Grid-Interfaced SRM Water Pump," in *IEEE Transactions on Consumer Electronics*, vol. 68, no. 4, pp. 366-375, Nov. 2022.
9. K. Lu, X. Lei and F. Blaabjerg, "Artificial Inductance Concept to Compensate Nonlinear Inductance Effects in the Back EMF-Based Sensorless Control Method for PMSM," in *IEEE Transactions on Energy Conversion*, vol. 28, no. 3, pp. 593-600, Sept. 2013.
10. M. N. Ibrahim, H. Rezk, M. Al-Dhaifallah and P. Sergeant, "Solar Array Fed Synchronous Reluctance Motor Driven Water Pump: An Improved Performance Under Partial Shading

Conditions," in *IEEE Access*, vol. 7, pp. 77100-77115, 2019.