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PV Array Fed Switched Reluctance Motor Driven Water Pumping System with Grid Interactive Control Technique

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***Abstract*— This paper presents a comprehensive review of the PV array-fed switched reluctance motor (SRM) driven water pumping system with a grid-interactive control technique. The integration of photovoltaic (PV) arrays with SRM technology offers an efficient and sustainable solution for water pumping applications, particularly in off-grid and remote areas. The study explores the advantages of using SRMs, known for their rugged construction and high efficiency, in conjunction with PV arrays to drive water pumps. The review also delves into the grid-interactive control techniques, which allow for the seamless operation of the water pumping system either in stand-alone mode or in connection with the grid, enhancing the system's reliability and energy management.**

***Keywords*— Solar, Water Pumping System, Photovoltaic, Sustainable Solution, Irrigation, MATLAB.**

I. INTRODUCTION

The global demand for sustainable and reliable water pumping solutions is on the rise, driven by the need to address water scarcity, particularly in rural and off-grid areas. Traditional water pumping systems, often reliant on grid electricity or diesel engines, pose significant challenges due to their high operational costs, environmental impact, and dependence on non-renewable energy sources. As a result, there has been a growing interest in integrating renewable energy sources, such as photovoltaic (PV) arrays, into water pumping systems. PV array-fed water pumping systems harness solar energy, which is abundant, renewable, and environmentally friendly, making them an ideal solution for remote locations with limited access to conventional energy sources.

Among various motor technologies used in water pumping systems, the switched reluctance motor (SRM) has gained attention due to its unique characteristics. SRMs are known for their simple and robust construction, high efficiency, and ability to operate over a wide range of speeds. Unlike traditional motors, SRMs do not require permanent magnets or rotor windings, which simplifies their design and reduces costs. These attributes make SRMs particularly suitable for use in PV-fed water pumping systems, where efficiency, durability, and cost-effectiveness are critical considerations.

The integration of PV arrays with SRM-driven water pumps presents several advantages. PV systems generate electricity directly from sunlight, providing a clean and renewable energy source for the motor. The combination of PV arrays with SRMs ensures that the water pumping system can operate efficiently even under varying solar conditions. Moreover, SRMs are highly compatible with the variable nature of solar power, as their performance is less sensitive to changes in input voltage compared to other motor types. This makes them well-suited for solar applications, where power fluctuations are common.

However, one of the major challenges of PV-fed water pumping systems is the variability of solar energy, which can lead to intermittent operation and reduced system reliability. To address this issue, grid-interactive control techniques have been developed. These techniques enable the water pumping system to operate in conjunction with the grid, allowing for the seamless transition between grid power and solar power. When solar energy is insufficient, the system can draw power from the grid, ensuring continuous operation. Conversely, excess solar energy can be fed back into the grid, enhancing overall energy management and reducing the reliance on non-renewable energy sources.

The grid-interactive control technique also allows for the optimization of energy usage, balancing the load between the grid and the PV system. This not only improves the efficiency of the water pumping system but also provides economic benefits by reducing energy costs and maximizing the use of renewable energy. Additionally, the ability to interact with the grid ensures that the water pumping system can contribute to grid stability, particularly in regions with high solar penetration.

II. METHODOLOGY

The SRM drive was selected for the present system because of its highly inductive nature, which makes it most ideal for single stage systems. This is the primary contribution that the current research study has made, and it may be summarized as follows:

It is suitable for use as a grid-interactive solar powered water pump since it has a cheap cost, a high efficiency, and the necessity of a simple power converter for phase energizing.

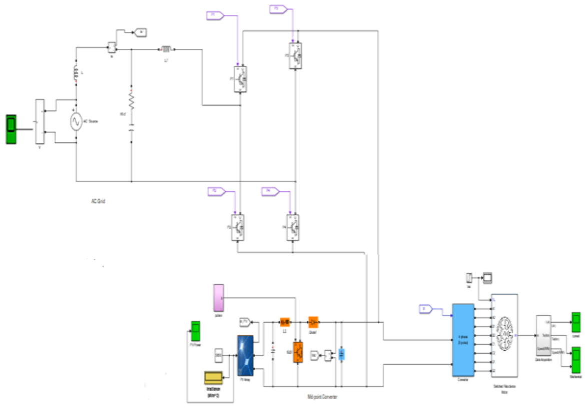

Figure 1: Proposed Model

Standard Solar has constructed one of the first solar microgrid systems in the US to include a grid-interactive battery bank. This system was designed and built by Standard Solar. Being the first to do anything was a challenge, and it required a significant amount of dedication, innovative engineering, and cooperation with essential partners, utilities, and government offices in order to make this project a reality. The core component of this effort will focus on laying the groundwork by elaborating on the configuration of the microgrid, as well as its practical applications and distinguishing characteristics.

Solar Panel

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MPPT Algorithm

Maximum power point tracking, also known as MPPT, is a calculation that is carried out in photovoltaic (PV) inverters. Its purpose is to continuously adjust the impedance that is seen by the solar cluster. This ensures that the PV system continues to operate at or close to the maximum power point of the PV panel, even when the conditions around it change, such as the amount of solar irradiance, the temperature, and the load. Calculations using MPPT are carried out by engineers when they are developing solar inverters in order to increase the amount of electricity that is generated by PV frameworks. The calculations regulate the voltage in order to make sure that the system operates at the "maximum power point" (also known as the highest voltage) on the power voltage curve, as will be illustrated in the following paragraphs. Calculations from an MPPT are often used in the framework designs for regulators for PV systems.

Microgrid

An electrical lattice is a network of linked organizations that is used to distribute electricity from its generators to its consumers.

It is made up of power generating stations that generate electrical power, high voltage transmission lines that carry electricity from far sources to demand centres, and distribution lines that connect individual customers to one another. An AC/AC converter that has approximately sinusoidal information currents and bidirectional power stream may be recognised by linking a pulse-width modulation (PWM) rectifier and a PWM inverter to the DC-interface. This allows for the converter to have bidirectional power flow. The DC-connect quantity is then influenced by an energy storage component that is common to the two phases. This component might be a capacitor C for the voltage DC-interface or an inductor L for the current DC-interface. Both of these components are referred to as DC-interface components. The

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PWM rectifier is operated in such a way that it draws a sinusoidal AC line current that is either in stage or against stage (for energy feedback) with the stage voltage of the corresponding AC line.

Switched Reluctance Motor (SRM)

An electric motor that is powered by its reluctance torque is referred to as a switched reluctance motor (SRM). Power is supplied to the windings in the stator (case) of the motor, as opposed to the rotor, which is in contrast to the typical brushed DC motor types. This considerably works on mechanical design since force does not need to be conveyed to a moving element, but it complicates the electrical design because some kind of exchanging framework has to be used to convey capacity to the numerous windings in the motor. Electronic devices are able to precisely timing exchange, which encourages the use of SRM systems. Its primary drawback is something called torque ripple. There has been an illustration of a regulator invention that reduces torque ripple at low speeds. There are conflicting reports on whether or not this device is a stepper motor.

III. SIMULATION RESULTS

The Current method is implemented using MATLAB 9.4, as stated in the previous sentence (R2018a). The simulation toolbox makes it possible for us to utilise the functions included in the MATLAB Library for a variety of different models. Some of the blocks included in this toolbox are scope, sink sin generator, and so on.

Grid-connected PV- Water Pumping System

When analysing the power exchange between the grid and the PV system in a grid-connected system, such as the microgrid system that is linked here, the PV power and the rated grid power are taken into consideration.

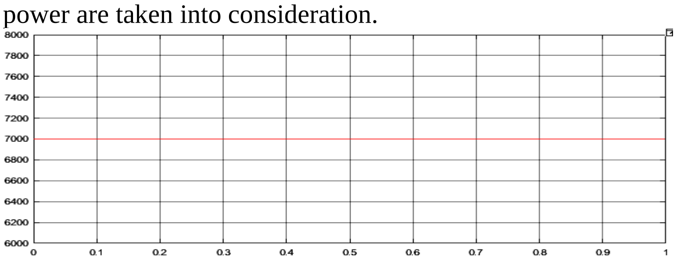

Figure 2: PV Power

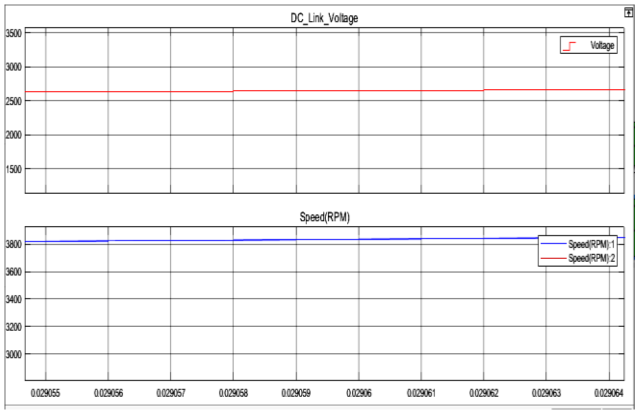

Figure 3: Speed versus time and Speed versus time

Figure 2 and 3 illustrates the grid-connected situation, the output performance of the PV power, the motor speed, and the DC link voltage values according to the simulation waveform. Figure 6(a) shows the PV power is 7000W, Figure 6(b) shows the DC link voltage is 2600V in the first sub plot and the speed of the motor is 3800rpm in the second sub plot.

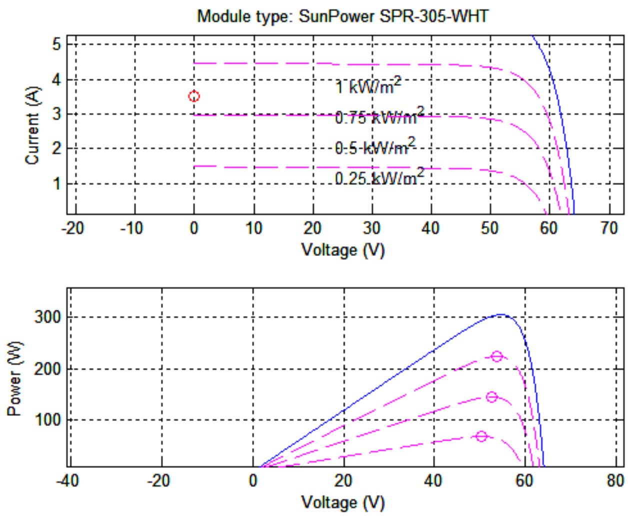

Figure 4: IV and PV waveform -1

The IV and PV waveforms are seen here in Figure 4. A measurement of an I-V curve is accomplished by subjecting the device in question to a succession of voltages. Measurements are taken of the current that is going through the device at each different voltage. The current is measured by an ammeter that is connected in series to the device, while the voltage that is delivered is measured by a voltmeter that is connected in parallel to the device.

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Table 1: Simulation Result when single solar panel

Sr. No	Parameter	Value
1	Sun Power	Single panel
2	Current	5A
3	Voltage	60V
4	Power	300W

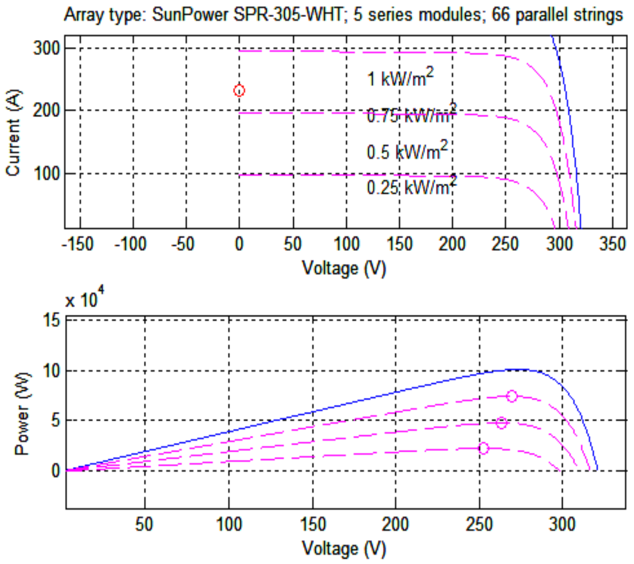

Figure 5: IV and PV waveform-2

Figure 5 depicts the solar panel array that was used. 5 of series modules and 66 parallel strings array types were used for the solar panel.

Table 2: Simulation Result when array solar panel

Sr. No	Parameter	Value
1	Sun Power	Array
2	Current	300A
3	Voltage	320V
4	Power	1,00000W

Table 2 is showing the performance parameters of array solar in water pumping system.

Table 3: Results comparison

Sr. No	Parameter	Previous Work	Present Work
1	Solar Panel Type	Array	Array
2	Current	20 A	5A (single), 300A (Array)
3	Power	8300W	Upto 1,0000 W
4	Speed	5000	14500

The comparison of the results of the prior model simulation with those of the proposed model simulation is shown in Table 3. Using MPPT control methods, the solar panel array is used for either the production of solar power or the collection of solar electricity. The earlier model work was based on an intelligent grid integrated solar photovoltaic (PV) powered water pumping system driven by three-phase reluctance synchronous motor (RSM) drive, and the new model work is based on grid interactive (GI) control techniques with a Solar PV based water pumping system driven by switched reluctance motor. Both of these systems are powered by solar photovoltaic cells (SRM).

IV. CONCLUSION

The sunlight based photovoltaic (PV) framework that is utilized to drive the water siphoning framework produces its own power, which is then used to control the framework. The engine siphon set is fueled by the power produced by the photovoltaic exhibit, which changes the sunlight based energy into usable structure. This study frames the plan of a sun powered photovoltaic (PV) based water siphoning framework that integrates an improved control technique. Exchanged hesitance engines give various benefits over different sorts of electric engines, including more control adaptability, a more clear design, diminished assembling costs, and further developed energy use. The MATLAB-SIMULINK program is utilized to do the recreation. The consequences of the reproduction demonstrated the way that the engine could achieve a higher RPM with a more prominent measure of force yield from the sun based. Along these lines, we might conclude from the results of the recreation that the ongoing model produces predominant results regarding speed, voltage, current, and power.

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