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An Intelligent Grid Integrated Solar PV Array Fed SRM Motor based Water Pumping System

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***Abstract*— Solar energy such as photovoltaic is the most promising energy of the non-conventional energy sources which is capable to satisfy the energy needs of the isolated rural areas. This paper presents a design of solar photovoltaic based water pumping system with improved control technique. The novel scheme of fundamental switching of SRM drive over its maximum operational time makes system efficient and reliable. Simulation is done using MATLAB simulink software. Simulated results show significant improvement in present model performance than existing model performance.**

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

I. INTRODUCTION

Solar Photovoltaic (PV) technology enables direct conversion of sunlight into electricity. Photovoltaic cells, commonly known as solar cells, are used to convert light (photon) in to electricity. Most of the commercially available solar cells are made from high purity silicon wafers. Solar cells can also be made from several materials such as silicon thin films both multi crystalline and amorphous, cadmium telluride (CdTe), copper indium diselenide (CIS), gallium arsenide (GaAs) etc. A number of solar cells are joined together to make a solar photovoltaic module. The electrical output of a solar cell / PV module is rated in terms of peak watt (Wp), which is the maximum power output that the PV module could deliver under standard test conditions (STC) of (i) incident solar radiation of 1000 watts per square meter area, (ii) spectral distribution of solar radiation as Air mass 1.5; and (iii) measurements being made at 25^0C ambient temperature. A combination of solar modules in series/ parallel combination, storage battery, interface electronics, mechanical support structure, cable and switches etc. constitute a solar photovoltaic (PV) system. A photovoltaic system can be used to provide electricity for lighting, water pumping and battery charging as well as for feeding power to the grid etc. Some of the advantages of solar PV systems are the long-life, reliability, and no recurring requirement of fuel, low maintenance and no pollution.

As abundant solar radiation is available in most parts of India SPV systems can be used anywhere in the country However, it is necessary to store energy generated by SPV systems in storage batteries for use in non-sunshine hours.

The photovoltaic technology is one of the most promising ways to generate electricity in a decentralized manner at the point of use for providing electricity, especially for lighting and meeting small electricity needs especially in un-electrified households and unmanned locations. Fossil fuels are fast depleting and therefore, it is essential to develop renewable sources of energy to meet our long term energy requirements. Solar energy can meet the growing requirements of energy effectively. Solar Photovoltaic (SPV) devices, which produce electricity directly from the sun light, are the ideal source to meet future energy requirements. Solar Water Pumping systems in particular are totally pollution-free and require very little maintenance as compared to the diesel operated/AC operated pump sets. The Solar Pumps can go a long way in promotion of these systems. During summers, a solar pump works for 8-10 hours and is idle to operate a drip/ fogger system with 2-5 H.P. motor.

Figure 1: Solar power water pumping system

Heaters and to meet domestic loads. The cost of solar panels has been constantly decreasing which encourages its usage in various sectors.

II. PROPOSED MODEL METHODOLOGY

The main contribution of the proposed research work is as followings-

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The SRM drive has been chosen for proposed system due to its highly inductive nature, which makes it most appropriate for single stage system.

The other benefits such as low cost, high efficiency and requirement of simple power converter for phase energizing, make it suited for the grid interactive solar powered water pump.

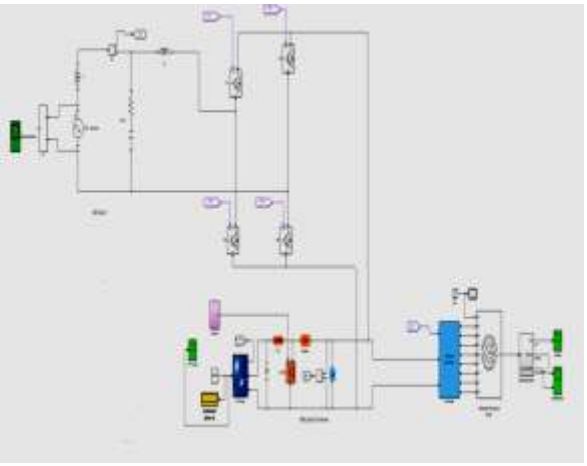

Figure 2: Proposed Model

Standard Solar, as of late finished one of the primary solar microgrid frameworks with a grid interactive battery bank in the nation. Being a first was a test it took a very long time of commitment, creative engineering and coordination with key accomplices, utilities and government workplaces to make this undertaking a reality. The primary portion of this work will set the stage by clarifying how the microgrid is arrangement, its usefulness and what makes it extraordinary.

Maximum power point tracking (MPPT) is a calculation executed in photovoltaic (PV) inverters to ceaselessly change the impedance seen by the solar cluster to keep the PV framework working at, or near, the pinnacle power point of the PV panel under differing conditions, such as changing solar irradiance, temperature, and burden.

The description of flow chart is as followings sub modules-

- Solar panel
- Maximum Power Point Tracking (MPPT)
- Microgrid
- DC-DC Boost converter
- DC-AC converter
- AC-DC converter
- Switched Reluctance Motor(SRM)
- Pulse width modulation(PWM)
- Improved GI

Solar Panel

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MPPT Algorithm

Maximum power point tracking (MPPT) is a calculation executed in photovoltaic (PV) inverters to ceaselessly change the impedance seen by the solar cluster to keep the PV framework working at, or near, the pinnacle power point of the PV panel under differing conditions, such as changing solar irradiance, temperature, and burden.

Microgrid

It comprises of creating stations that produce electrical power, high voltage transmission lines that convey power from inaccessible sources to request focuses, and dissemination lines that associate individual clients. An AC/AC converter with around sinusoidal info currents and bidirectional power stream can be acknowledged by coupling a pulse-width modulation (PWM) rectifier and a PWM inverter to the DC-interface.

DC-DC Boost converter

This part gives a depiction and review of power electronic technologies including a portrayal of the major frameworks that are the structure squares of power electronic frameworks.

AC-DC converter

AC-DC converters have been created to a developed level with improved power quality as far as power-factor rectification, diminished complete sounds contortion at input ac mains, and controlled dc yield in buck, boost, buck-boost, staggered and multipulse modes with unidirectional and bidirectional power stream.

Switched Reluctance Motor (SRM)

The switched reluctance motor (SRM) is an electric motor that runs by reluctance torque. In contrast to normal brushed DC motor sorts, power is conveyed to windings in the stator (case) as opposed to the rotor. This significantly works on mechanical plan as force doesn't need to be conveyed to a moving part, however it confounds the electrical plan as a type of exchanging framework should be utilized to convey capacity to the various windings. Electronic gadgets can exactly time exchanging, encouraging SRM setups.

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Its principle downside is torque ripple. Regulator innovation that limits torque ripple at low speeds has been illustrated. Sources differ on if it is a sort of stepper motor.

Pulse Width Modulation (PWM)

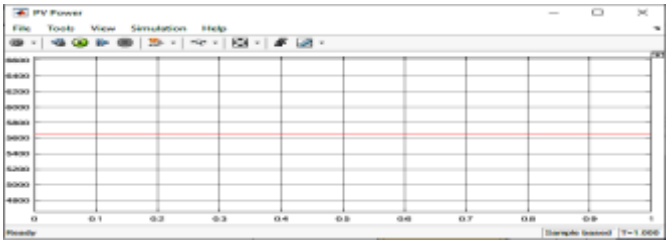
The generation of a sinusoidal PWM signals, which discovers more applications in enterprises. The gating sign can be produced by contrasting a sinusoidal reference signal and a three-sided transporter wave and the width of each pulse changed relatively to the sufficiency of a sine wave assessed at the focal point of a similar pulse.

III. Simulation Results

The implementation of the proposed algorithm is done over MATLAB 9.4.0.813654 (R2018a).

Stand-alone PV Water Pumping System

Case-I: In stand-alone system, when PV-power is 5650W, the motor runs at rated speed i.e. 14000 rpm by giving output as 5650 W.



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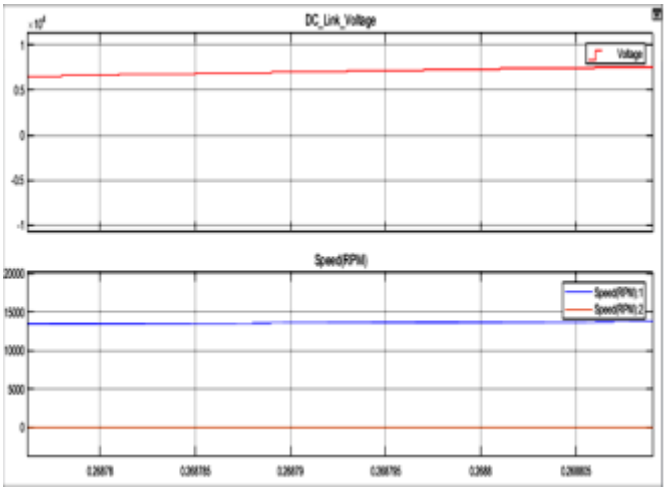
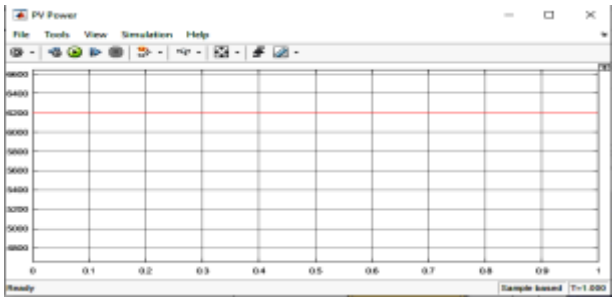


(b)

Figure 3: Performance of standalone solar water pumping system (a) DC-link voltage vs time (b) Speed vs time

Figure 3 is showing the output performance of the PV power, motor speed and DC link voltage. Here it is clear from the waveform the PV power is 5650W, motor speed is 14000rpm and DC link voltage is 6000V.

Case-II: When PV-power increases to 6200 W, speed and power output of motor increased to 14000 rpm to 14250 rpm respectively.



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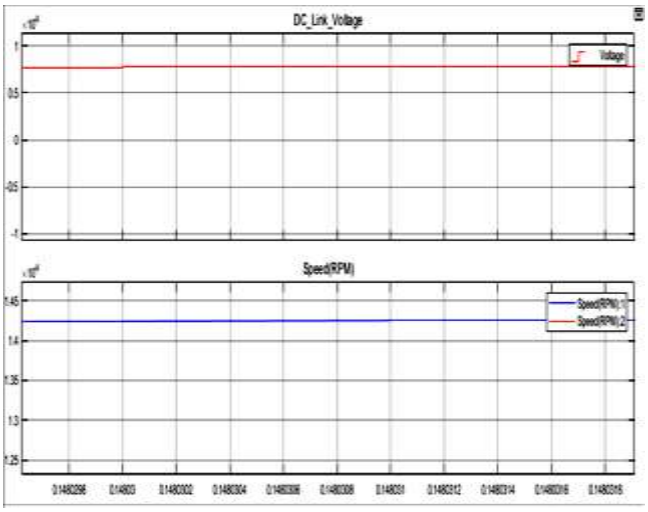

(b)

Figure 4: Performance of standalone solar water pumping system (a) DC-link voltage vs time (b) Speed vs time

Figure 4 is showing the output performance of the PV power, motor speed and DC link voltage. Here it is clear from the waveform the PV power is 6200W, motor speed is 14250rpm and DC link voltage is 7500V.

Case-III: When PV-power decreased to 2583 W then motor output and speed reduces to 3500 rpm. The power variation of the above mentioned scenarios and the speed variation of SRM motor in accordance with the change in PV-power.

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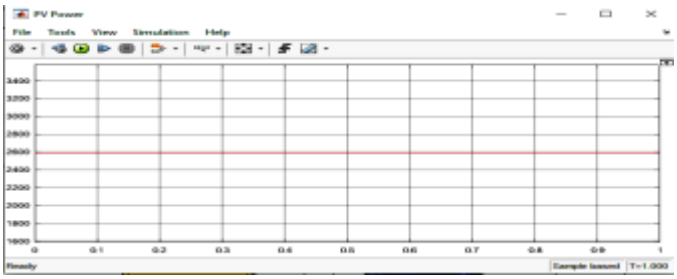

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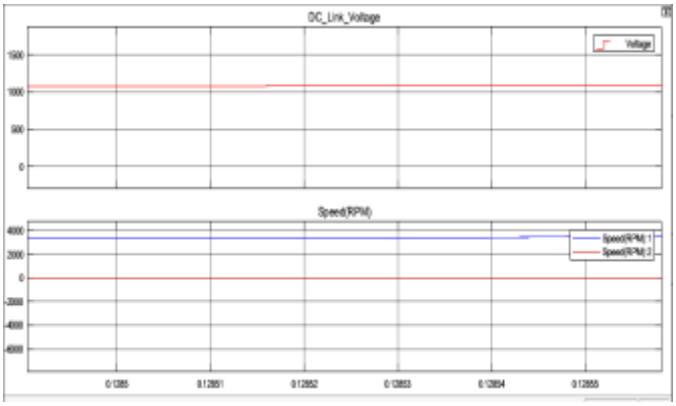


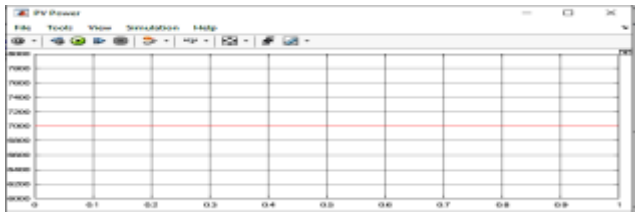
(b)

Figure 5: Performance of standalone solar water pumping system (a) DC-link voltage vs time (b) Speed vs time

Figure 5 is showing the output performance of the PV power, motor speed and DC link voltage. Here it is clear from the waveform the PV power is 2583W, motor speed is 3500rpm and DC link voltage is 1100V.

Grid-connected PV- Water Pumping System

In grid-connected system, here connected the microgrid system, the power exchange between grid and PV system is analyzed by considering PV power and rated grid power.



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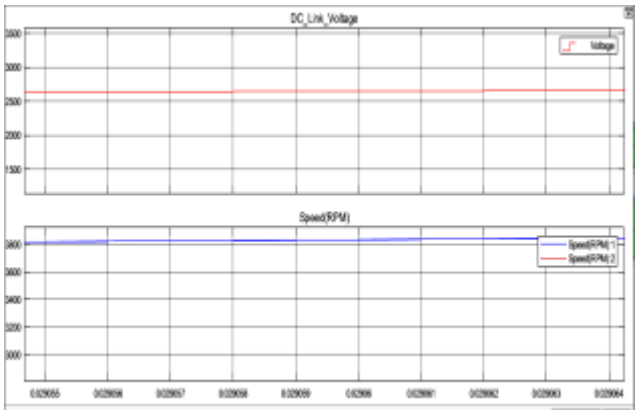

(b)

Figure 6: Performance of grid connected solar water pumping system (a) DC-link voltage vs time (b) Speed vs time

Figure 6 is showing the grid connected condition, the output performance of the PV power, motor speed and DC link voltage values as per the simulation waveform. Therefore the PV power is 7000W, motor speed is 3800rpm and DC link voltage is 2600V.

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

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	Proposed 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

Table 3 is showing the result comparison of the previous and the proposed model simulation results. The solar panel array is used for the generation or collecting the solar power with MPPT control techniques. The previous model work is based on the intelligent grid integrated solar photovoltaic (PV) powered water pumping system driven by three-phase reluctance synchronous motor (RSM) drive and the proposed model work is based on the grid interactive (GI) control techniques with Solar PV based water pumping system driven by switched reluctance motor (SRM).

IV. Conclusion

The solar PV based water pumping system operates on power generated using solar PV (photovoltaic) system. The photovoltaic array converts the solar energy into electricity, which is used for running the motor pump set. This research proposeds the design of solar PV based water pumping system with improved control technique. The switched reluctance motor provides many benefits against other types of electric motors because of its control flexibility, simple structure, lower cost and high efficiency. The Simulation is performed using the MATLAB-SIMULINK software. Simulation results achieved better RPM of motor with more power generation from the solar. Therefore, from the simulation results it can be say that the proposed model is giving the better results in terms of speed, voltage, current and power.

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