DESIGN OF SOLAR PV BASED WATER PUMPING SYSTEM WITH GRID INTERACTIVE CONTROL TECHNIQUE

[1]Khushboo Sinha, [2]Ms. Alka Thakur
[1]Research Scholar, [2]Assistant Professor & HOD
Department of Electrical Engineering, School of Engineering
Sri Satya Sai University of Technology and Medical Sciences, Sehore, India

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 water pumping system functions only during the sunshine hours, thereby eliminating the use of costly battery bank. These pumping systems are ideal for small/middle farmers to meet their irrigation requirements.

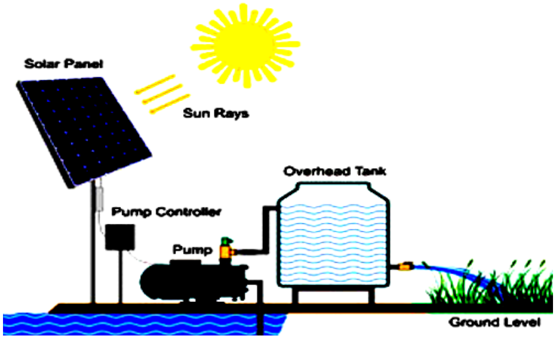

Figure 1: Solar power water pumping system

The cost of solar panels has been constantly decreasing which encourages its usage in various sectors.

II. PRESENT MODEL METHODOLOGY

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

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

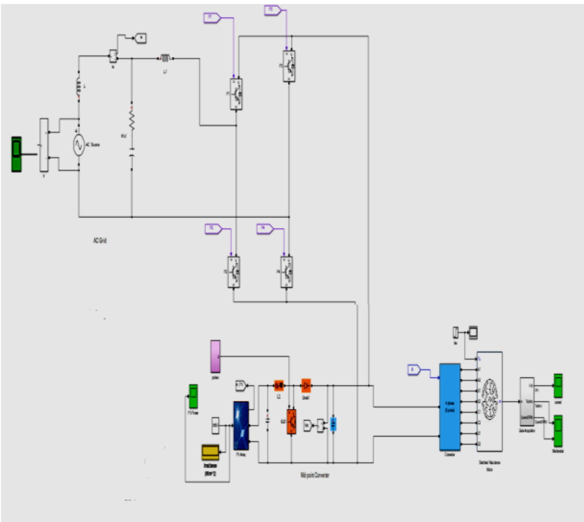

Figure 2: Proposed Model

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. At that point I will investigate the stuff to plan and introduce a solar microgrid framework, the exercises gained from this historic task and what specialized contemplations should be made while executing this new innovation.

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

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.

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. Engineers creating solar inverters execute MPPT calculations to boost the power produced by PV frameworks.

Microgrid

An electrical lattice is an interconnected organization for conveying power from makers to customers. 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.

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. Technologies that are portrayed include: power semiconductor exchanging gadgets, converter circuits that cycle energy starting with one DC level then onto the next DC level, converters that produce variable recurrence from DC sources, standards of redressing AC input voltage in uncontrolled DC yield voltage and their augmentation to controlled rectifiers, converters that convert to AC from DC (inverters) or from AC with fixed or variable yield recurrence (AC regulators, DC/DC/AC converters.

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 multiples modes with unidirectional and bidirectional power stream. Three stage ac-dc transformation of electric power is generally utilized in movable velocities drive (ASDs), uninterruptible power supplies (UPSs), HV dc frameworks and utility interfaces with nonconventional fuel sources.

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.

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 model is done over MATLAB 9.4.0.813654 (R2018a).

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.

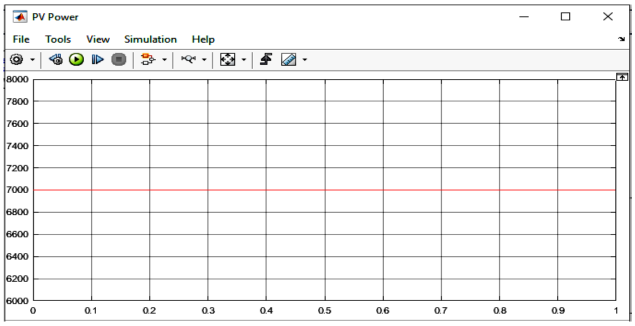

Figure 3: PV Power

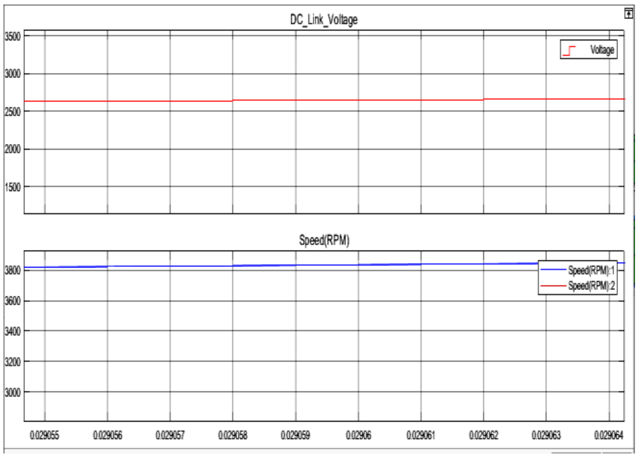

Figure 4: (a) DC-link voltage vs time (b) Speed vs time

Figure 4 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.

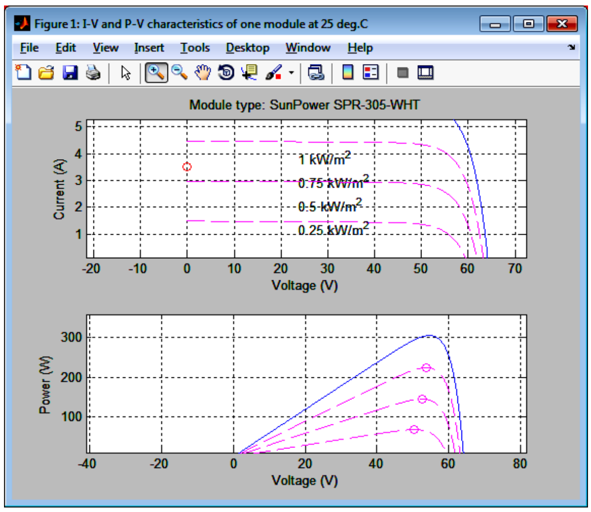

Figure 5: IV and PV waveform -1

Figure 5 is showing the IV and PV waveform. An I-V curve measurement is performed by applying a series of voltages to the device. At each voltage, the current flowing through the device is measured. The supplied voltage is measured by a voltmeter connected in parallel to the device, and the current is measured by an ammeter connected in series.

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

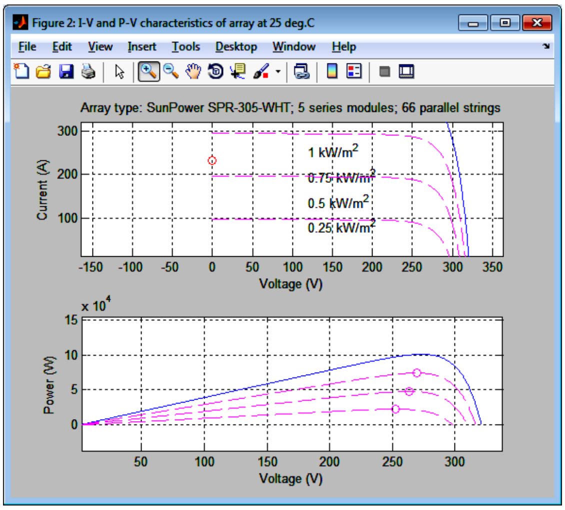

Figure 5: IV and PV waveform-2

Figure 5 is showing the solar array panel. % series modules and 66 parallel strings array type solar panel used.

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	300A
3	Voltage	600 V	640 V
4	Power	8.3KW	Upto 1,00KW
5	Speed	5000 RPM	14500 RPM

Table 3 is presenting 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).

V. 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 presents 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 present model is giving the better results in terms of speed, voltage, current and power.

REFERENCES

1. A. Varshney, U. Sharma and B. Singh, "An Intelligent Grid Integrated Solar PV Array Fed RSM Drive-Based Water Pumping System," in IEEE

Transactions on Industry Applications, vol. 57, no. 2, pp. 1818-1829, March-April 2021, doi: 10.1109/TIA.2020.3045952.

2. I. Akhtar, S. Kirmani, M. Suhail and M. Jameel, "Advanced Fuzzy-Based Smart Energy Auditing Scheme for Smart Building Environment With Solar Integrated Systems," in IEEE Access, vol. 9, pp. 97718-97728, 2021, doi: 10.1109/ACCESS.2021.3095413.
3. A. A. Stonier et al., "Fuzzy Logic Control for Solar PV Fed Modular Multilevel Inverter Towards Marine Water Pumping Applications," in IEEE Access, vol. 9, pp. 88524-88534, 2021, doi: 10.1109/ACCESS.2021.3090254.
4. M. Kashif and B. Singh, "Solar PV Fed Reverse Saliency Spoke-Type PMSM with Hybrid ANF Based Self-Sensing for Water Pump System," in IEEE Journal of Emerging and Selected Topics in Power Electronics, doi: 10.1109/JESTPE.2021.3084129.
5. S. Angadi, U. R. Yaragatti, Y. Suresh and A. B. Raju, "Comprehensive review on solar, wind and hybrid wind-PV water pumping systems-an electrical engineering perspective," in CPSS Transactions on Power Electronics and Applications, vol. 6, no. 1, pp. 1-19, March 2021, doi: 10.24295/CPSSTPEA.2021.00001.
6. H. Rezk, M. Al-Dhaifallah, Y. B. Hassan and H. A. Ziedan, "Optimization and Energy Management of Hybrid Photovoltaic-Diesel-Battery System to Pump and Desalinate Water at Isolated Regions," in IEEE Access, vol. 8, pp. 102512-102529, 2020, doi: 10.1109/ACCESS.2020.2998720.
7. R. Rai, S. Shukla and B. Singh, "Sensorless Field Oriented SMCC Based Integral Sliding Mode for Solar PV Based Induction Motor Drive for Water Pumping," in IEEE Transactions on Industry Applications, vol. 56, no. 5, pp. 5056-5064, Sept.-Oct. 2020, doi: 10.1109/TIA.2020.2997901.
8. S. Shukla and B. Singh, "Single-Stage PV-Grid Interactive Induction Motor Drive With Improved Flux Estimation Technique for Water Pumping With Reduced Sensors," in IEEE Transactions on Power Electronics, vol. 35, no. 12, pp. 12988-12999, Dec. 2020, doi: 10.1109/TPEL.2020.2990833.
9. S. Murshid and B. Singh, "Single Stage Autonomous Solar Water Pumping System Using PMSM Drive," in IEEE Transactions on Industry Applications, vol. 56, no. 4, pp. 3985-3994, July-Aug. 2020, doi: 10.1109/TIA.2020.2988429.
10. K. Khan, S. Shukla and B. Singh, "Improved Performance Design Realization of a Fractional Kilowatt Induction Motor With Predictive Current Control for Water Pumping," in IEEE Transactions on Industry Applications, vol. 56, no. 4, pp. 4575-4587, July-Aug. 2020, doi: 10.1109/TIA.2020.2968014.
11. Parsai, Neha, Alka Thakur, and M. dan Tech. "PV Curve-Approach for Voltage Stability Analysis. & quot; International Journal of Information Technology and Electrical Engineering 4.2 (2015) 46-52.