

# Switched Reluctance Motor Drive in SPV Water Pumping System

Jisha Anna Mathew<sup>1</sup>, Juna John Daniel<sup>2</sup>

P.G. Student, Department of Electrical and Electronics Engineering, Sree Buddha Engineering College, Pattoor, Kerala, India<sup>1</sup>

Associate Professor, Department of Electrical and Electronics Engineering, Sree Buddha Engineering College, Pattoor, Kerala, India<sup>2</sup>

**ABSTRACT:** Solar power is an attractive source of energy, free, abundant and nonpolluting the atmosphere. However, due to the lower efficiency of current photovoltaic cells, conversion of sunlight into electrical power is very poor and its irradiance level, array temperature dependents, this efficiency further decreases if there is no impedance matching between photovoltaic panels output and the load ensure that the maximum power transfer theorem is fulfilled. This paper presents a solar photovoltaic (SPV) array fed water pumping system employing a switched reluctance motor (SRM) drive. The aim of this paper is to show how to achieve an effective photovoltaic pumping system without batter storage this system is simple and consists of a switched reluctance motor driving a pump powered by a PV array. This motor is cheaper, efficient and reliable than conventional AC and DC electrical machines used in this application. This is because of its simple construction. The SRM drive at fundamental frequency offers reduced switching losses in the mid-point converter and increases the efficiency of the proposed system. A DC-DC Cuk converter operating in continuous conduction mode (CCM). The CCM operation decreases the losses of DC-DC converter. For smooth input/output current Cuk converter of SRM drive with the region for maximum power point tracking (MPPT). By adjusting the step size of an incremental conductance (InC) MPPT algorithm can facilitate the soft starting of SRM drive. The proposed system, shows the effectiveness and robustness of the proposed method for increasing pumping performance.

**KEYWORDS:** Continuous conduction mode (CCM), Cuk converter, Incremental conductance (InC), Maximum power point tracking, Switched reluctance motor (SRM).

## I. INTRODUCTION

Providing clean and safe water sufficient quantities, protecting health and ensuring sustainable development are the major concern for farmers and ranchers [2]. Abundant water supply in remote location is required to ensure grazing evenly. PV water pumping is one of the developing applications of solar energy on which considerable attention is being paid in order to increase its overall efficiency. The pumping system consist of PV array, a motor, and a pump. Solar energy based water pumping system is efficient, reliable and cost effective for livestock watering irrigation purposes and for supply of water for domestic applications in remote locations.

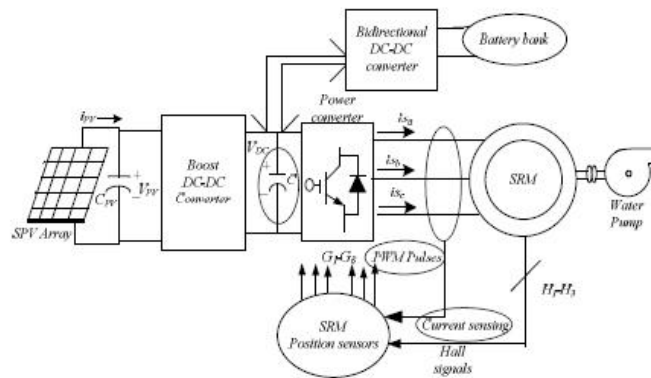
Different DC and AC motors have been proposed so far in SPV array based water pumping system. Induction Motor is a well-developed motor[1]. It is simple, cheap and reliable, but it requires complex inverters to convert DC power to AC power with minimum harmonics. Thus, as the complexity increases its reliability in service decreases. On the other hand DC motor is the most complicated and expensive motor. It suffers from maintenance problems due to the presence of the commutator and brushes. DC motor are also associated with arching problems which limits motor size and speed range. SPV powered permanent magnet motors for water pumping application using various maximum power point tracking techniques.

The DC motor, PMSM and an induction motor are compared and concluded that the special machines are better choice for global efficiency optimization of SPV fed water pumping system. The downside of brushless DC motor (BDCM) drive system is a complex control strategy and complicated inverter topology. The major drawback with these motors is the phenomenon known demagnetization of permanent magnets.

Among all special machines, the switched reluctance motor (SRM) has the simplest construction [3]. Switched reluctance machines (SRM) have been considered serious candidates for a variety of industrial applications including automotive, aerospace, and military. This is primarily due to their rugged structure, robustness to operational conditions, and relatively high efficiency over a wide range of speeds. The rotor of SRM contains no conductors or permanent magnets. Therefore the detection of rotor position becomes an integral part of any potential control algorithm. Hall-effect sensors to detect rotor position generally contribute to unreliability, additional cost, and an increased size. SRM could be a suitable candidates for water pumping powered by SPV array. Moreover the stator windings of SRM are electrically separated; hence, the choice of converter topology and control strategy has more flexibility than any other drive system.

Both the SRM and the permanent magnet (PM) machines are free of rotor copper loss but the SRM phases are independently controlled by the converter which makes the short circuit current decay quickly while in the PM machines the short circuit current persist as long as the machine continues to rotate due to back-emf generation . The robust brushless construction and good thermal features make the SRM drive attractive for a SPV powered water pumping system. Many topologies of a SRM drive water pumping system have been reported in the literature but each suffer for disadvantages like absence of MPPT tracker, requiring large number of sensors, system complexity and use of battery..

## II. CONVENTIONAL SCHEME



**Fig.II Conventional SPV and battery fed SRM driven water pumping system**

Figure shows a conventional scheme of SPV fed boost converter based water pumping system utilising SRM drive. It consist of a SPV array, a boost converter, a battery with a bidirectional converter and a three phase SRM together with its drive circuit and water pump which is proposed. In this figure the output voltage of the panel is tracked by MPPT is used to extract maximum power from PV module. The output of the MPPT is given to the boost DC-DC converter. The output of the converter is given to power converter. The power converters are used for fast switching operation. To improve the overall efficiency of the inverter and to reduce the input capacitances, a DC-DC bidirectional converter is used. Here fundamental switching of the converter are generated through the Hall Effect sensors situated at the stator part of the SRM and the output is given to drive the pump. This type of scheme has its own drawbacks like reduction in efficiency and reliability due to the operating voltage of the whole system which is fully regulated by battery in spite of SPV array and additional losses due to bidirectional converter. The other limitations of the system are absence of MPPT operation, high SRM inverter losses due to pulse width modulation switching and its complexity.

### III. PROPOSED SCHEME

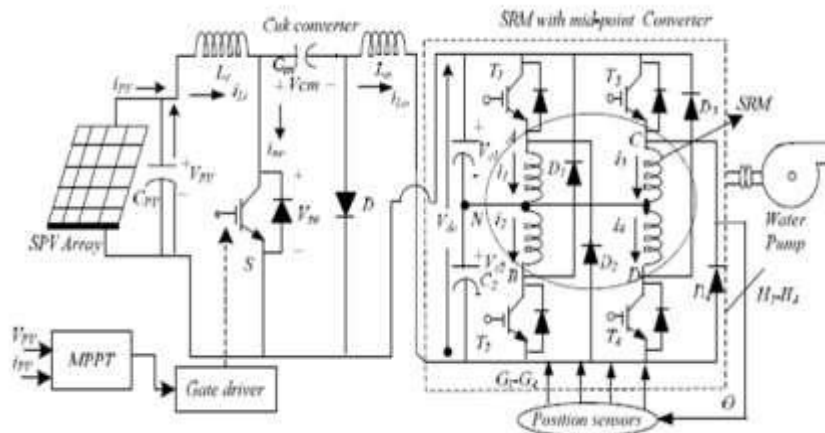


Fig.III Proposed SPV fed SRM driven water pumping system utilizing Cuk converter

Figure shows the proposed SPV array fed water pumping system utilizing a Cuk converter and employing SRM drive. It consists of the SPV array, a Cuk converter, the mid-point converter feeding the SRM and a coupled water pump. The output voltage of the panel is tracked by MPPT is used to extract maximum power from PV module the output of the MPPT is given to gate drive which drives the Cuk converter. The Cuk converter is designed to operate in continuous conduction mode in which current is continuous this helps to reduce voltage and current stress on the device. The output of the Cuk converter is given to the SRM with mid-point converter. In this it is split into two halves using split capacitors. During conduction period the energy is supplied to the phases by one half of the power supply. During turn off period the phases demagnetize into other half of the power supply. When the power semiconductor  $T_1$  is turned on and the phase winding A is energised by the capacitor  $C_1$ . When  $T_1$  is turned off the stored energy in phase winding A is feedback to the capacitor  $C_2$  through the diode  $D_2$ . When  $T_2$  is turned on the phase winding B is energized by the capacitor  $C_2$ . When  $T_2$  is turned off the energy stored is feedback to the capacitor  $C_1$  through diode  $D_1$ . Here fundamental switching of the mid-point converters are generated through the Hall Effect sensors which is situated at the stator part of the SRM and the output is given to drive pump.

### IV. COMPARATIVE ANALYSIS OF CONVENTIONAL AND PROPOSED SCHEME

This section deals with the comparative study of two configuration of SPV fed water pumping system employing SRM drive. The proposed cuk converter fed SRM drive water pumping is compared with conventional SRM driven water pumping system. In conventional scheme MPPT is absent and in proposed scheme it's present. In conventional scheme of SRM drive its complex while in proposed scheme it's simple due to the present of midpoint converter. In conventional topologies efficiency is low and in proposed system it's high. In conventional scheme cost is high due to lots of converters used while in proposed system its low. In conventional scheme losses are high due to additional losses of bidirectional DC-DC converters while in proposed scheme its low.

### V. CONCLUSION

The SPV array fed SRM driven water pumping system using Cuk converter has been introduced. The performance of proposed system has been found quite well for varying environmental conditions. A variable voltage of DC bus has been used for controlling the speed of SRM drive which has given freedom for the electronic commutated operation of mid-point converter which leads to reduced switching losses of converter. The Continuous Conduction Mode operation of Cuk converter has also boosted the efficiency of proposed water pumping system by reducing voltage and current stresses on devices of Cuk converter and increasing power output of Cuk converter by lowering the ringing effect of system. Experimental and simulated results have very much close which has validated the model of the proposed SPV fed water pumping employing SRM drive.

### REFERENCES

- [1] Bhim Singh, Anjana kumar, and Rajan Kumar, "Solar Powered Water Pumping System Employing Switched Reluctance Motor Drive" IEEE Transactions on Industrial applications 2016, pp. 1-8.
- [2] S. G. Malla, C. N. Bhende, and S. Mishra, "Photovoltaic based water pumping system," *Int. Conf. Energy, Automation Signal (ICEAS)*, 28-3 Dec. 2011, pp. 1-4.
- [3] S. Belliwali, A. Chakravarti and A.B. Raju, "Mathematical modelling and simulation of directly coupled PV water pumping system employing Switched Reluctance Motor," *IEEE PES Innovative Smart Grid Technologies - India (ISGT India), 2011*, pp.no.386-390, 1-3 Dec. 2011.
- [4] V. Bist and B. Singh, "PFC Cuk Converter-Fed BLDC Motor Drive," *IEEE Transactions on Power Electronics*, vol.30, no.2, pp.871-887, Feb.2015.
- [5] G.J.Kish, J.J. Lee and P.W. Lehn, "Modelling and control of photovoltaic panels utilising the incremental conductance method for maximum power point tracking," *IET Renewable Power Generation*, vol.6, no.4, pp.259- 266, July 2012.
- [6] Bhim Singh and Rajan Kumar, "BLDC Motor-Driven Solar PV array- fed water pumping system employing Zeta converter" *IEEE Transactions on Industrial applications* vol.52,no3,May/June 2016