# A Solar powered water pumping framework using Switched Reluctance Motor

[1]Vijayaraja L, [2] Dhanasekar R, [3]Rupa Kesavan

[1]Assistant Professor, [2]Assistant Professor, [3]Assistant Professor
[1,2]Electrical and Electronics Engineering,
[1,2]Sri Sairam Institute of Technology, Chennai, India
[3]Computer Science and Engineering,
[3]Prince Shri Venkateshwara Padmavathy Engineering Colloge, Chennai, India

***Abstract :*** Nowadays there is a great advancement in using Solar Photo Voltaic array for many purposes. A simple design and MATLAB simulation of a solar water pumping framework using Switched Reluctance Motor is proposed here. Switched Reluctance Motor possessing a number of advantages over the DC and AC motors such as high torque density, low inertia, quick response and low losses because of the absence of permanent magnet or any winding on the rotor. It also exhibits wide speed range capability and simple control for the Solar Photo Voltaic array powered water pumping system. For the smooth and continuous operation of the proposed scheme a Cuk converter and Midpoint converter is designed in the circuit. Maximum Power Point Tracking algorithm is used as an intermediate DC-DC converter between the Solar Photo Voltaic array and the Midpoint converter, in order to operate the Solar Photo Voltaic array at its optimum power point. The proposed system achieves better efficiency and output than that of a conventional water pumping system.

***IndexTerms* - Solar photo voltaic, Switched Reluctance Motor, Cuk Converter,Maximum Power Point Tracking.**

## I. INTRODUCTION

Giving non-contaminated water fit for use in adequate amounts, thus securing wellbeing and guaranteeing maintainable improvement are the significant area of concern for cattle rearing people and farmers. Plentiful water supply in remote areas is required to guarantee the feeding and other domestic needs. Solar powered photovoltaic (SPV) exhibit based water pumping is most acknowledged and respected due to use of sun as an energy source. Solar energy dependant array for water pumping is productive, dependable and savvy for domesticated animals watering, water system purposes and for supply of water for residential applications in remote areas[1]-[2].

Apart from special machines like Switched Reluctance motor [3]-[4], distinctive DC and AC engines have been proposed so far for SPV cluster based water pumping framework. The issues related with DC engines are the standard support frequently because of nearness of commutator and brushes. On the opposite side, AC engines are powerless to work at low speeds, complex control and low unwavering quality. SPV controlled permanent magnet machines, be it brushless type or synchronous operation type, utilize different Maximum Power Point Tracking (MPPT) strategies [5] have been contemplated making use of different DC-DC converter circuits. The DC engine[6], PMSM[7] and an Induction machine[8]-[9] are analyzed and finally it is reasoned that the special purpose machines are the best choice for worldwide productivity and improvement of SPV nourished water pumping system. The drawback of brushless DC engine (BDCM) drive frameworks is a complicated control technique and entangled inverter topology. The significant downside with these engines is the irreversible demagnetization of the magnets used. Among every special electrical machine, the SRM plays vital role [10]. The rotor of SRM contains no conductors or permanent magnets. Many different choices of converter topologies are proposed for the SRM [11]-[12].

The discussion is made on two of the models commonly in design and proposes an alternate third one with certain improvements. The designs to be viewed here are:

1. Conventional SPV With Battery For SRM Water Pumping Scheme
2. Conventional SPV With Battery voltage controller For SRM Water Pumping Scheme:

A Switched Reluctance Motor has several advantages over a conventional AC, DC or induction machine. The most appreciable features of a reluctance motor are as follows:

1) Windings are on the stator only, with no windings or magnets on the rotor, thus saving materials on the rotor.
2) The concentric windings also reduce the end-turn buildup, thus minimizing the inactive part of the materials and resulting in lower resistance and copper losses
3) They produce better output due to continuous operation and high speeds.
4) As the windings are electrically separate from each other and as they have negligible mutual coupling, electrical fault in one phase does not affect other phases, in general. Such a feature is unique to the switched reluctance motor.

Here, in section II describes the comparison of the various schemes and their shortcomings and section III gives an idea of the framework that is to be developed and the section IV gives the simulation data of the proposed work.

## II. COMPARISON OF THE VARIOUS WATER PUMPING SCHEMES EMPLOYING SWITCHED RELUCTANCE MOTOR

The figure fig2.1 demonstrates a customary plan of SPV based Boost converter based water pumping framework using SRM drive. It comprises 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. This kind of setup has its own disadvantages like reduced output and unwavering quality because of the output voltage of entire framework which is completely affected by the battery notwithstanding the SPV cluster and extra energy losses because of bidirectional converter. The other different drawbacks of this framework are lack of a MPPT design, high SRM inverter losses because of PWM action and its complicated design.

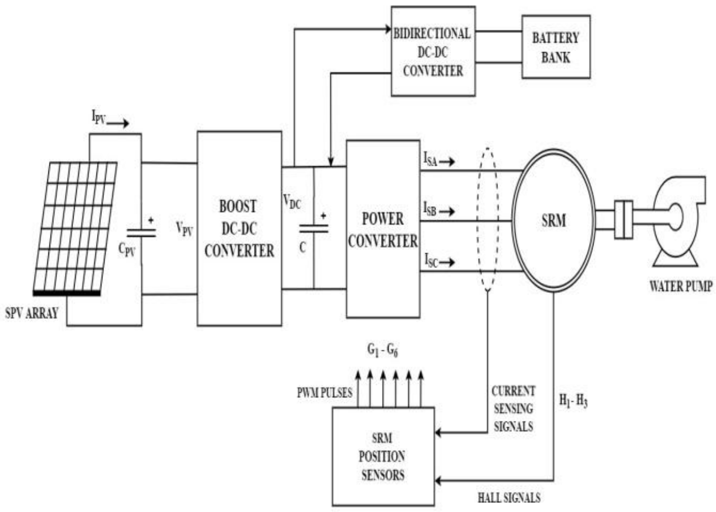


**Fig.2.1 Conventional SPV + Battery fed SRM water pumping scheme**

In fig.2.2 another method of SPV nourished water pumping utilizing SRM drive is proposed with an slight alteration. It comprises a battery associated with the SPV exhibit through a battery voltage controller (BVR) with the assistance of two switches. So other than Battery issues, losses are likewise more due to switching action. Also in addition, lack of MPPT technique diminishes the productivity of framework. The exchanging losses are limited by utilizing an idea of variable DC-interface voltage for speed control of the motor drive and it is concluded that the model is not productive and we have to work on building a more efficient model.

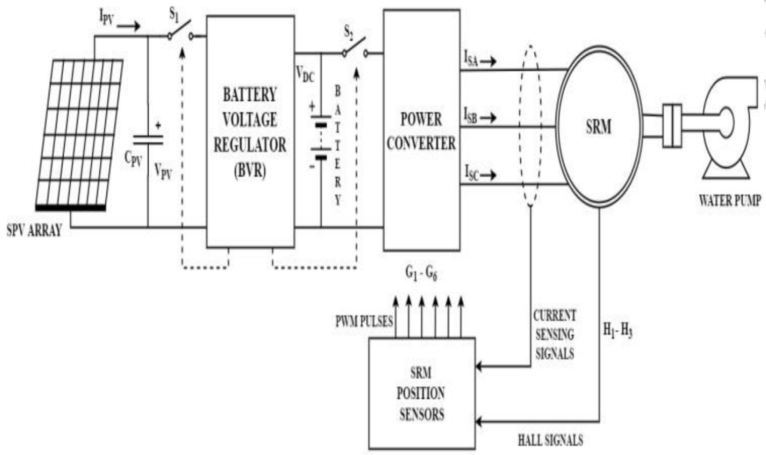


**Fig.2.2 Conventional SPV with Regulator fed SRM water pumping scheme**

## III. PROPOSED FRAMEWORK AND THE SIMULATION FOR THE SYSTEM

The proposed topology is designed in such a way that it overcomes the usual shortcomings and is made to run for a long period without much maintenance.

In fig.3.1 the proposed SPV cluster based water pumping framework using a Cuk converter and utilizing SRM drive is presented. It comprises of the SPV cluster, a Cuk converter, the mid-point converter encouraging the SRM and a coupled water pump. The Cuk converter is so designed and its parameters are chosen to work in Continuous Conduction Mode. The CCM operation of Cuk converter diminishes the current and voltage stresses on its devices what's more, to achieve the DC-DC change proportion autonomous of load. The issues exhibit in intermittent conduction mode like ringing effect which is because of the change of voltage at the other side of the inductor when the current becomes nil, causes electromagnetic interference and expanded switch voltage rating which are dispensed with in CCM operation of DC-DC Cuk converter. The pulses for main switching operations of the midpoint converter switches are created from the Hall Effect position sensors arranged on the stator part of SRM and its makes a difference to lessen the losses related with switches of a mid-point converter. The SPV cluster yield power is improved by InC MPPT method. A model of proposed design is additionally created to approve its execution for shifting insulation levels. The exploratory results are utilized to approve the value of proposed framework.

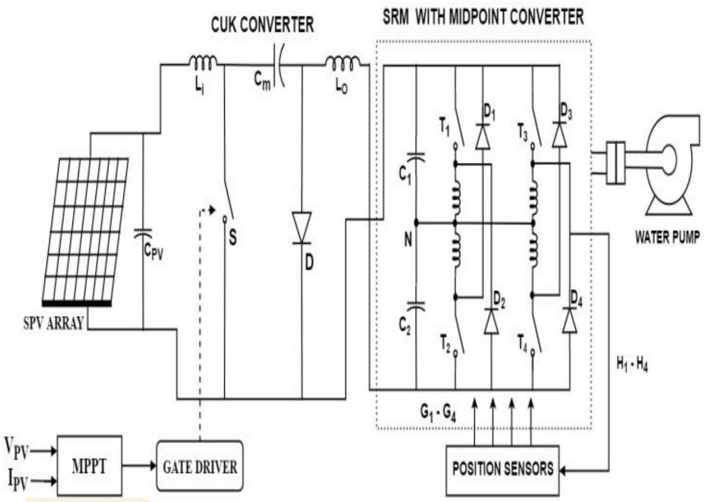


**Fig.3.1 Proposed Design**

## IV. SIMULATION DATA FOR THE PROPOSED SCHEME

The Simulation for the entire circuit can be achieved with the help of MATLAB and Simulink software. The entire proposed setup can be divided into various functional units that serve an effective function each.

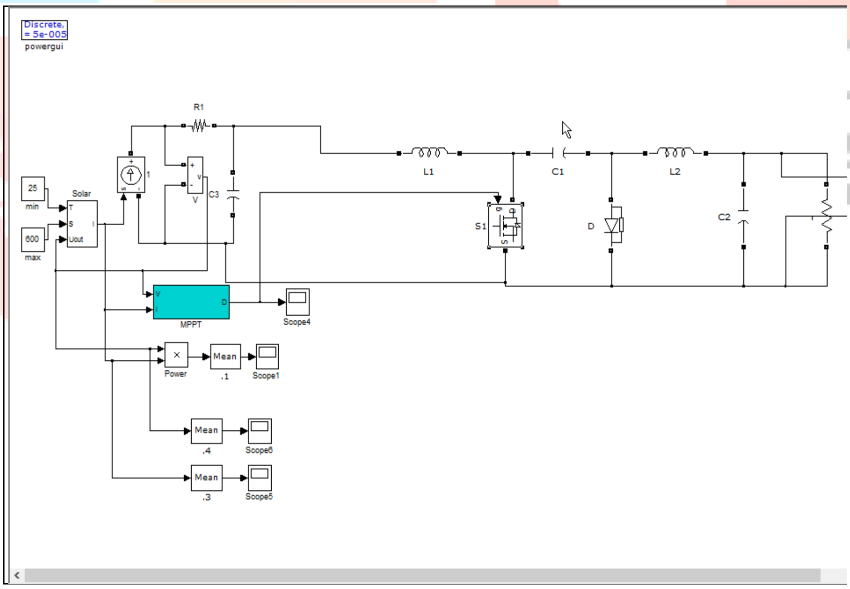


**Fig.4.1 PV and Cuk Converter Simulink model**

The DC-DC Cuk converter is planned in a manner that it continuously works in CCM paying little mind to the ecological conditions. The pinnacle and RMS current steams are significantly lower in CCM bringing about lower losses in the conduction ways and littler ringing in light of the fact that the energy put away in inductances is corresponding to the square of the current. A non-isolated Cuk converter design comprises two inductors, two capacitors, a switch (usually a transistor), and a diode. It is an inverting converter, so the output voltage is negative with respect to the input voltage. The capacitor C is used to transfer energy and is connected alternately to the input and to the output of the converter via the commutation of the transistor and the diode. The fig.4.1 describes the PV and Cuk converter circuit developed by Matlab simulation process.

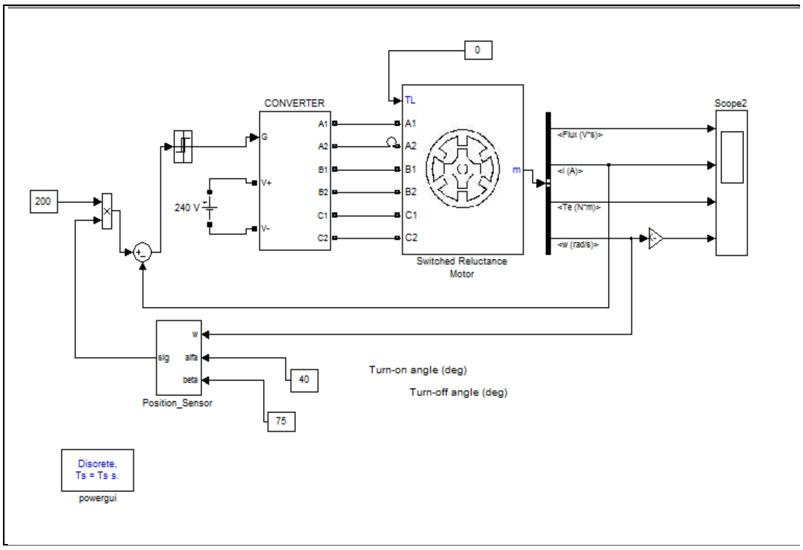


**Fig.4.2 Developed simulink model for SRM**

The proportionate circuit of SRM is demonstrated as a current controlled voltage source in fig.4.2. In this proportionate circuit, e(t) is the e.m.f. of the SRM. Because of the saliency on rotor and stator side, SRM has non-sinusoidal current and flux over every one of the four windings against the pulse voltage supply. The displaying is completed on the supposition that the attractive coupling between two back to back windings of SRM is unimportant and its stage inductance profile has the non-straight shape. The SRM is designed in such an arrangement that it is of 3 phase winding type, it has 6 stator poles and 4 rotor poles.

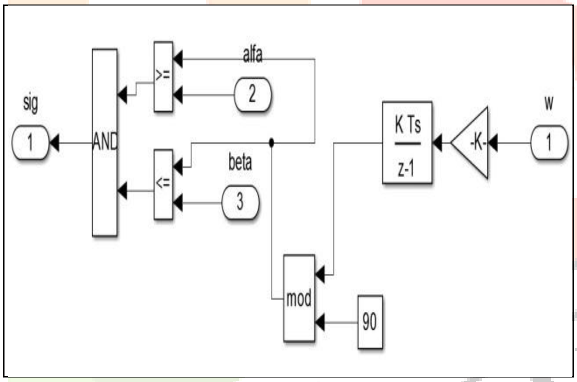


**Fig.4.3 Position Sensor Simulink Model**

The output from the converter is fed to the SRM circuitry and this has parameters like Current, flux, angular velocity and torque. This is fed to the position sensor described in fig.4.3 and according to the impulses received the control is ensured by the Hall effect position sensors.

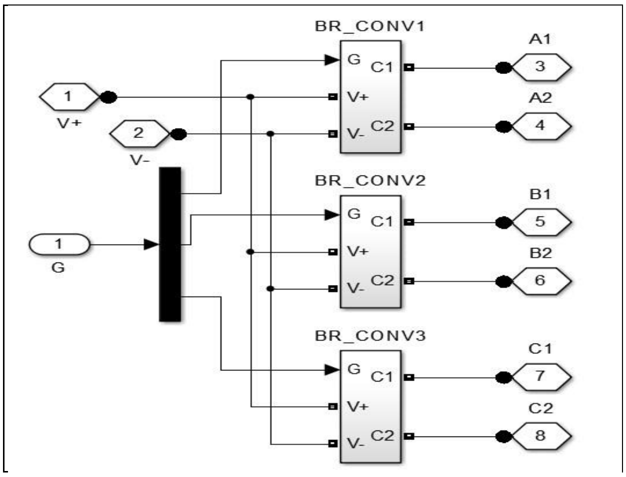


**Fig.4.4 Converter Design for SRM**

The Bridge Rectifier (BR) Converter design is achieved by assembling a set of 3 individual converters together.It is shown in the fig.4.4 as a simple design.

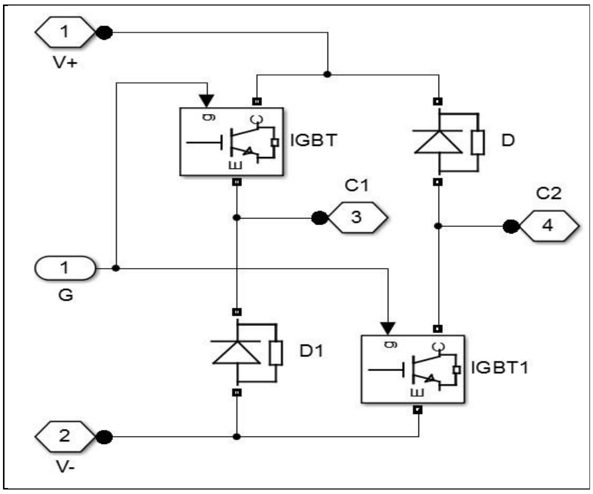


**Fig.4.5 SRM BR-Converter1**

The converter setup consists of two IGBTs and a diode pair which is provided with necessary input triggers. The IGBT is triggered by gate pulses and the diode action protects the circuitry from any damage in case of any faulty actions. The same design as in fig.4.5 is followed for two more converter units that are implemented in the circuitry.

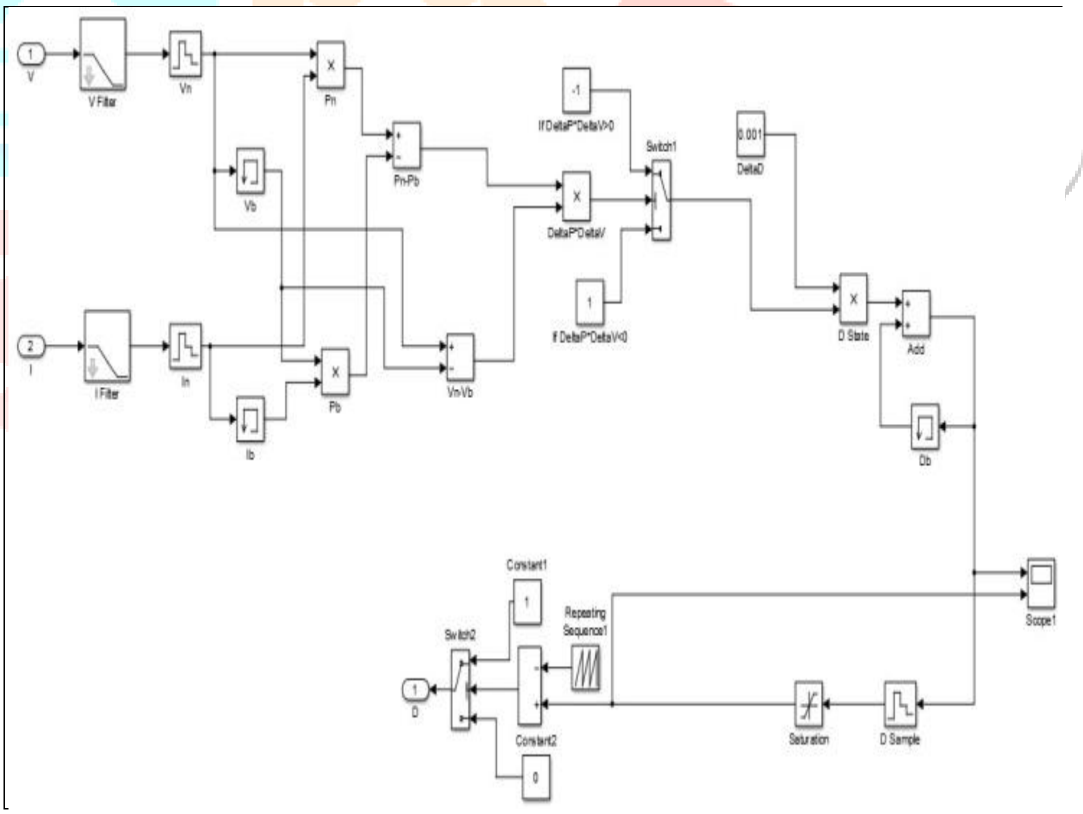


**Fig.4.6 MPPT Simulink Model**

The MPPT is an algorithm followed to increase the output and to maintain the output voltage constant. There are various techniques namely Perturb & Observe, Incremental Conductance etc. We follow Incremental Conductance Technique right here which is better than the P&O method in many aspects and a functional block is developed here in fig.4.6.

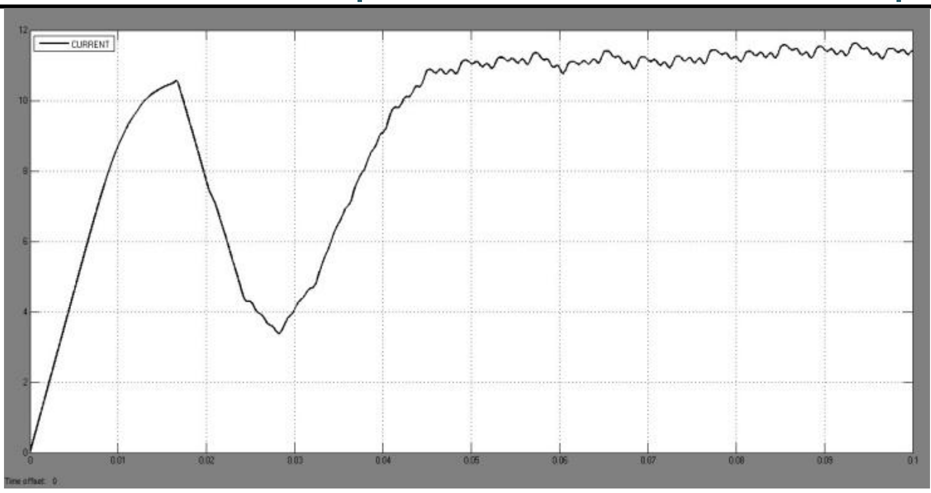


**Fig.4.7 Current Output ($I_{pv}$)**

The value of current is the range of 10 A in fig.4.7 and it experiences continuous rise and fall with increase in time accordingly and the varying level of solar heat radiation. The value of voltage is as high as 80V in the simulation results and this is a proof to the improved performance of the simulated framework in fig.4.8.

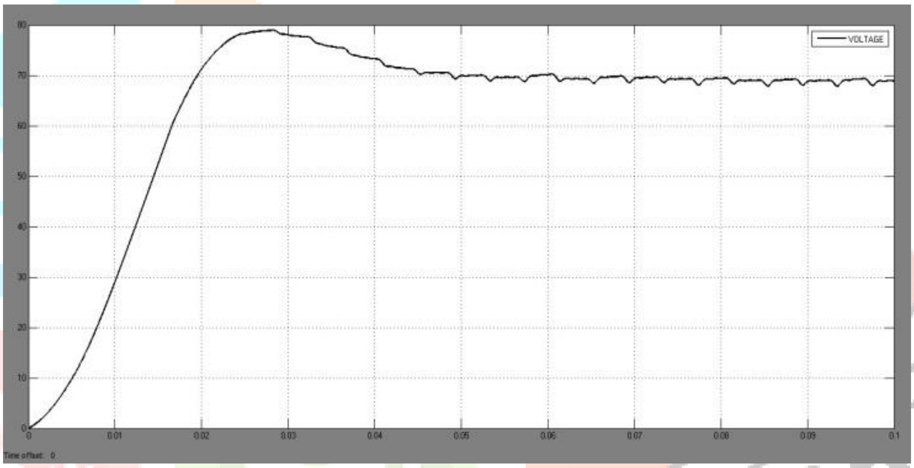


**Fig.4.8 Voltage Output ($V_{pv}$)**

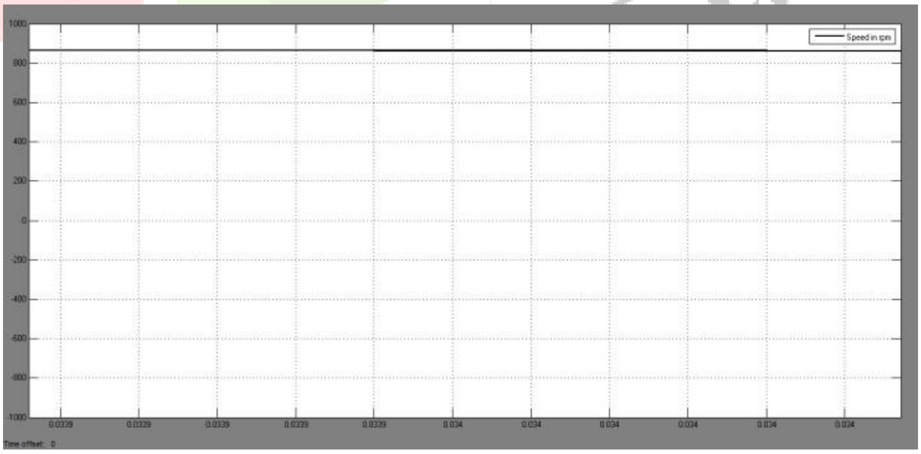

**Fig.4.9 Speed Output in RPM**

The speed lies in the range of 700-800 rpmin is shown in fig.4.9and this is appreciable for efficient operation in spite of the environmental constraints. When the framework is developed physically it may experience various physical constraints and this is also added in the simulated design to have an insight into the actual results. The value of output power is the deciding factor in knowing the actual performance of the developed model and it is in the range of 740-770W when designed as in fig.4.10.

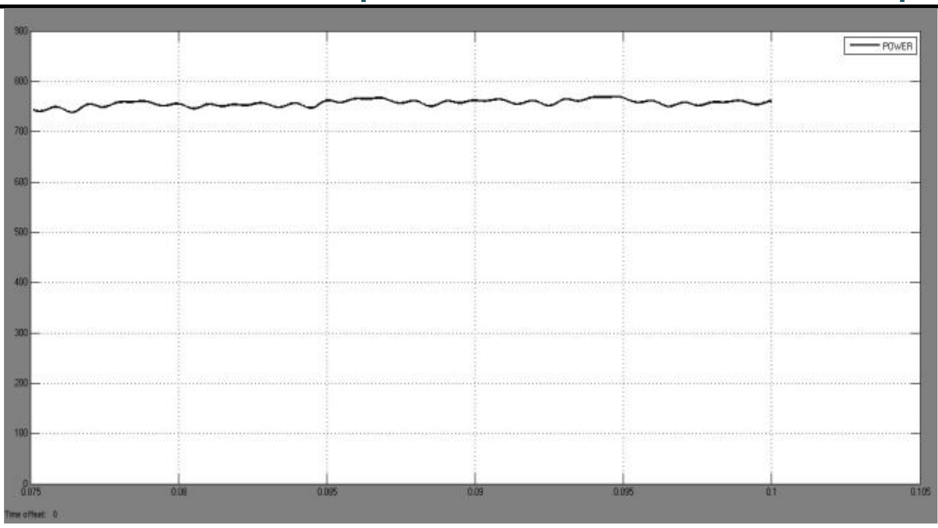

**Fig.4.10 Power output**

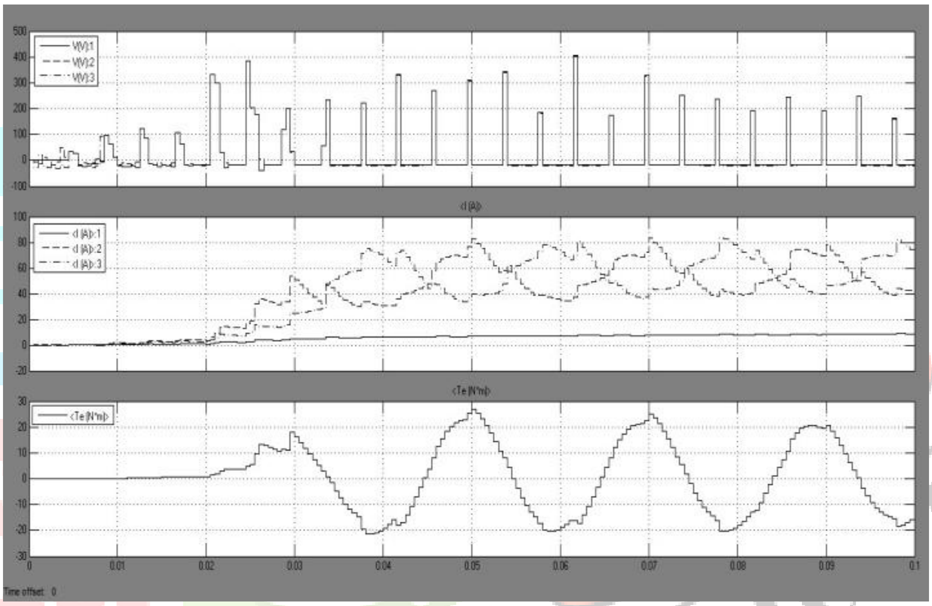

**Fig.4.11 Final Output Current, Voltage and Torque of SRM**

Appreciable gain and better efficiency are observed at the output side, the value of output voltage is around the range of 400Vand suitable current and torque characteristics are also exhibited for the same design. The value is about 10 to 20 Nm. This is represented in the fig.4.11.

## V. CONCLUSION

A simple design and MATLAB simulation of a solar water pumping framework using Switched Reluctance Motor is carried out. The following results obtained explain that the same design can be applied for building an efficient prototype for water pumping framework using Switched Reluctance Motor. The system achieves better efficiency than the late proposed water pumping system.

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