Asynchronous And Synchronous Machines (Asm)

MTE Project Report on

Simulation of Solar Water Pump

Submitted by

Illu(2K20/EE/129)

Mahima Vishwakarma(2K20/EE/157)

Muskan(2K20/EE/174)

Pradyumn Tiwari (2K20/EE/187)

Under the supervision of

Prof. Saurabh Mishra

Department of Electrical Engineering

Delhi Technological University
Bawana Road. Delhi -110042
May 2022

CANDIDATE'S DECLARATION

We are **Illu, Mahima Vishwakarma, Muskan, and Pradyumn Tiwari (2K20/EE/129,2K20/EE/157,2K20/EE/174, 2K20/EE/187)** students of B. Tech. **(Electrical Engineering)** hereby declare that the project Dissertation titled **"Simulation of Solar Water Pump"** which is submitted by us to the Department Electrical Engineering, Delhi Technological University, Delhi in partial fulfillment of the MTE Project is original and not copied from any source without proper citation. This work has not previously formed the basis for the award of any Degree, Diploma Associateship, Fellowship, or other similar title or recognition.

Place: Delhi

Date:May 2022

CERTIFICATE

I hereby certify that the project Dissertation titled **" Simulation of Solar Water Pump"** which is submitted by **Illu, Mahima Vishwakarma, Muskan, and Pradyumn Tiwari (2K20/EE/129,2K20/EE/157,2K20/EE/174, 2K20/EE/187) [Electrical Engineering]**, Delhi Technological University, Delhi in complete fulfillment of the requirement for the award of the degree of the Bachelor of Technology, is a record of the project work carried out by the students under my supervision. To the best of my knowledge this work has not been submitted in part or full for any Degree or Diploma to this University or elsewhere.

Place: Delhi
Date: May 2022

Subject Teacher
Mr. Saurabh Mishra

(Assistant Professor)

ACKNOWLEDGEMENT

The success and final outcome of this project required a lot of guidance and assistance from many people and we are extremely privileged to have got this all along with the completion of the project. All that is done is only due to such supervision and assistance and we shall not forget to thank them. We respect and thank **Prof. Saurabh Mishra** Delhi Technological University, for providing an opportunity to do the project work and giving us all support and guidance, which made us complete the project duly. We are extremely thankful to him for providing such vested support and guidance. We owe deep gratitude to him for taking a keen interest in our project work till the completion of our project work by providing all the necessary information for developing a well-structured project. We are thankful for and fortunate enough to get constant encouragement, support, and guidance from the Department which helped us in successfully completing our project work. Also, we would like to extend our sincere esteems to all the valuable suggestions put in by our peers and for their timely support.

ABSTRACT

Nowadays people are chasing alternate energy sources due to the paucity of non-renewable energy sources. Because of which they are moving towards renewable energy sources. This project presents the efficient use of solar energy by operating Photovoltaic (PV) panels at the maximum power point (MPP) for powering the water pump. Water is required for various purposes like drinking, irrigation, for domestic and industrial uses. So, water pumping has become an indispensable task in day-to-day life. Such mechanisms are very useful where other sources such as grid power supply and other renewable sources are not easily available. Here in this project, we are using a boost converter, as from solar energy, we did not get the exact power that we required for our load, we get a low power, because of different climatic conditions. so to extract the maximum power, we need to use the MPPT technique with a boost converter, so by using these two devices we can get the maximum power from the solar to meet the load requirements. An inverter is used to convert the dc voltage obtained from the boost converter to Ac voltage.

CONTENTS

Introduction

The introduction of a three-phase induction motor brings an improved solution to the commercial water pumping system. The SPV array fed water pumping system using IMD mainly consists of two stages; the first stage extracts the maximum power from the solar Photovoltaic (PV) array by restraining the duty ratio of the DC-DC boost converter. In the second stage, a controller is employed to control the switching pulses of the Voltage Source Inverter (VSI)**.**

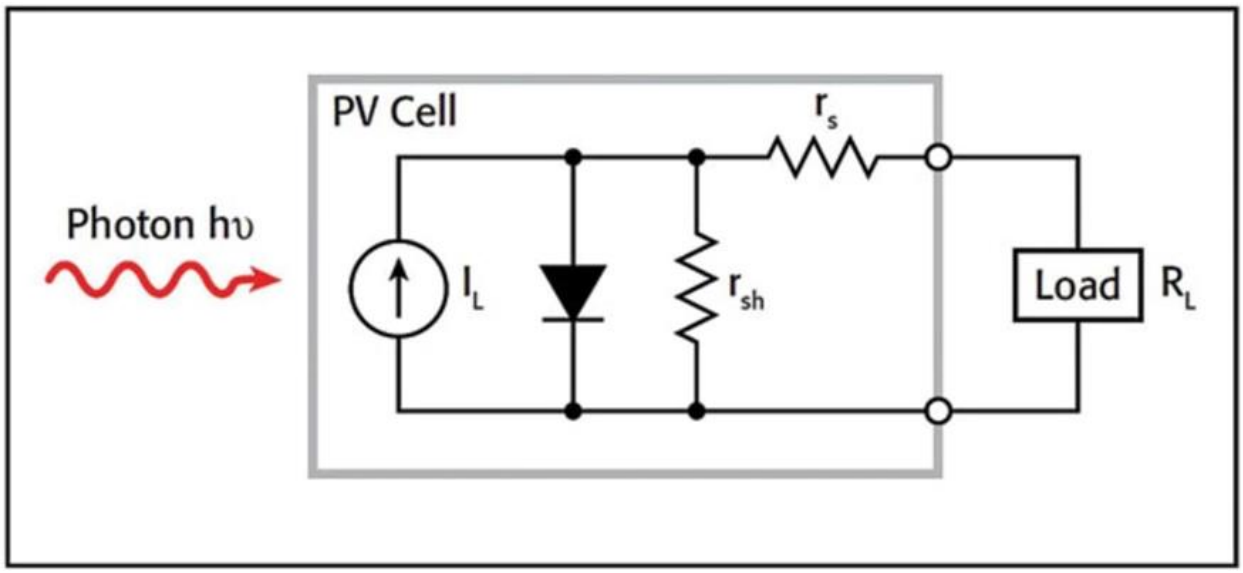
The proposed system consists of an arrangement of solar panels, a boost converter, a three-phase inverter, and a three-phase motor. The boost converter is used to enhance the power from the PV array and get constant DC output. Then the output from the boost converter is given to the induction motor. The centrifugal pump is driven by three-phase induction motors.
This can be achieved through modeling and simulation of the various stages that constitute the overall system. Simulation results are obtained using the MATLAB/Simulink environment for the effectiveness of the study.

Components of the System

- Solar PV Panel

A model of a PV module is used to predict module power. Temperature variations are not considered in this analysis and each module is assumed to be operated at 25°C. The simplest model of a PV cell is shown as an equivalent circuit below that consists of an ideal current source in parallel with an ideal diode.

There are two key parameters frequently used to characterize a PV cell. Shorting together the terminals of the cell, the photon generated current will follow out of the cell as a short circuit current (I_{sc}). Thus, $I_{ph} = I_{sc}$. When there is no connection to the PV cell (open circuit), the photon generated current is shunted internally by the intrinsic p-n junction diode. This gives the open circuit voltage (V_{oc}). The PV module or cell manufacturers usually provide the values of these parameters in their datasheets.



Circuit Diagram of solar PV panel

The output current (I) from the PV cell is found by applying Kirchhoff's current law (KCL) on the equivalent circuit.

$$I = I_{sc} - I_d \qquad (1)$$

Where I_{sc} is the short-circuit current that is equal to the photon generated current, and I_d is the current shunted through the intrinsic diode.

The diode current Id is given by the Shockley's diode equation:

$$Id = I_o(eqV_d/kT - 1) \qquad (2)$$

Where: Io is the reverse saturation current of the diode (A), q is the electron charge (1.602*10-19 Coulomb), V_d is the voltage across diode (V),
K is the Boltzmann's constant (1.381*10-23 J/K), T is the Junction temperature (Kelvin).

Replacing Id of the equation (1) by the equation (2) gives the current- voltage relationship of the PV cell,

$$I = I_{sc} - I_o(e^{\wedge}(qV_d/kT) - 1) \qquad (3)$$

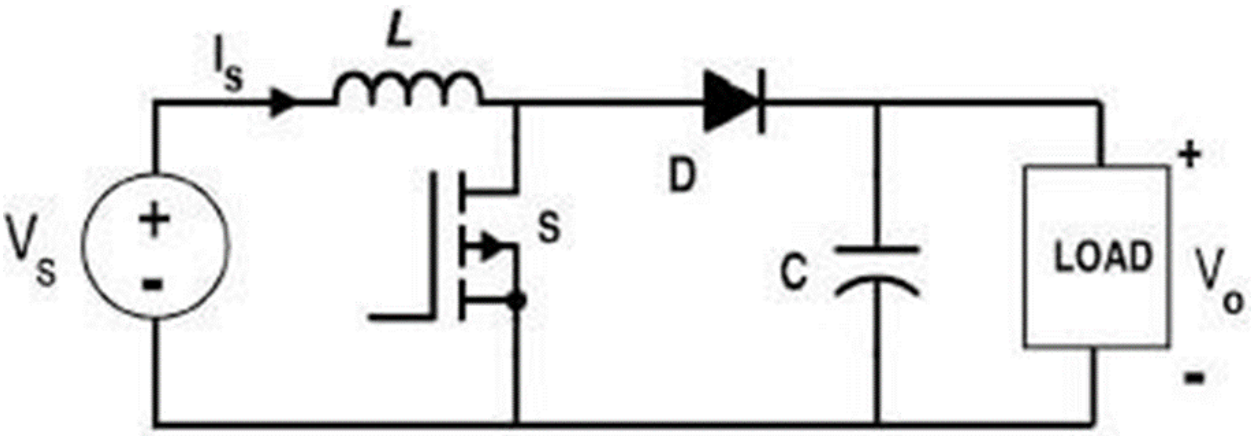
Total, Four Hundred Seventy solar cells are used in which a series of 10 solar cells are connected in parallel to form a string. The simulation for solar panels is implemented in MATLAB.

- ## DC-DC Boost Converter

DC-to-DC converter is an electronic circuit or electromechanical device that converts a source of direct current (DC) from one voltage level to another. It is a type of electric power converter.

In these DC-to-DC converters, energy is periodically stored within and released from a magnetic field in an inductor or a transformer. By adjusting the duty cycle of the charging voltage (that is, the ratio of the on/off times), the amount of power transferred to a load can be more easily controlled.

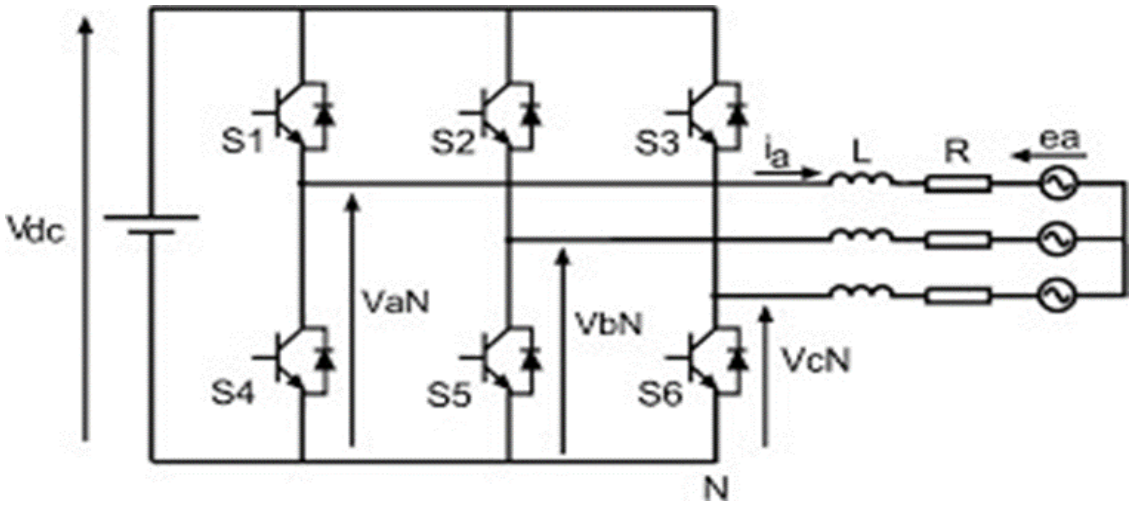
The configuration of boost converter for ON state and OFF state is described below by using switches. The output voltage equation for boost converter based on the duty cycle. Inductor L and capacitor C make up the effective output filter. Resistor R Load represents the load seen by the power supply output.



Circuit Diagram of Boost Converter

- Voltage Source Inverter

An inverter is a circuit that transforms DC to AC sources. Inverters are utilized as a part of an extensive variety of uses from little exchanged power supplies for a PC to vast electric utility applications to transport mass power. This makes them exceptionally appropriate for when you have to utilize AC control instruments or machines. In photovoltaic framework, the DC/AC inverter is utilized to change over the energy of the source by exchanging the DC input voltage in a pre-decided grouping to create AC voltages yield. Proportionate circuit of three-stage inverter is indicated figure below. It has six switches that turn on and off to get a sinusoidal yield. SPWM is a strategy that utilizes as a technique to abatement symphonies substance in the inverter circuit. There are two basic types of forced-commutated inverter: The current source inverter and the voltage source inverter.

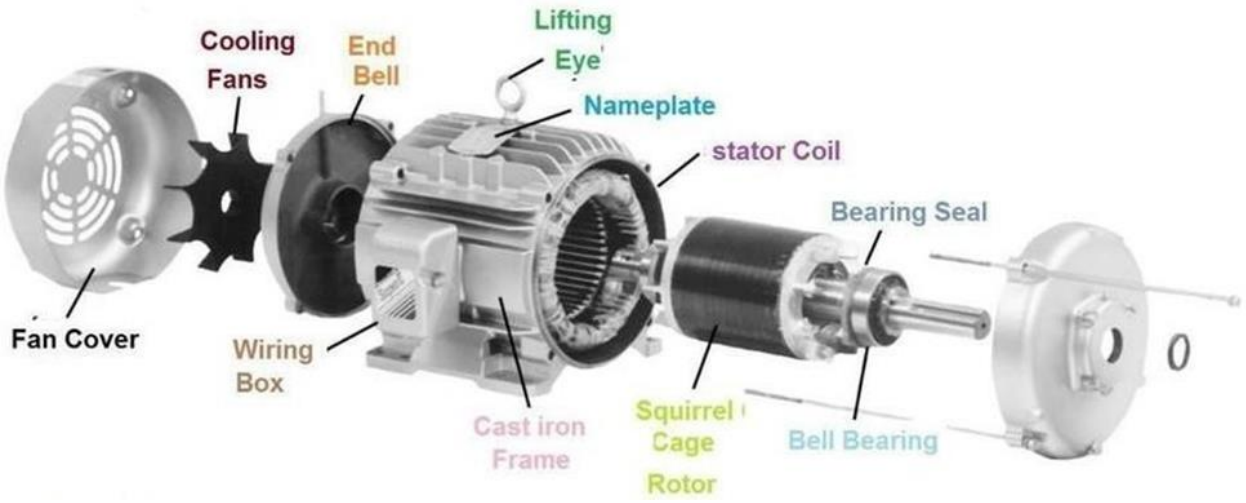


Circuit Diagram of Voltage Source Inverter

The DC voltage acquired from the PV array is changed over to AC voltage with the help of an inverter. A voltage source inverter gives a firm connection voltage, over the motor terminals. The load current alters itself as per the impedance of the motor. Here a six-step mode inverter is utilized to get a three-stage voltage output from a DC source.

- ## Induction Motor

Induction motor used in this project is Squirrel Cage Induction Motor. A 3-phase squirrel cage induction motor is a type of three phase induction motor which functions based on the principle of electromagnetism. It is called a 'squirrel cage' motor because the rotor inside of it – known as a 'squirrel cage rotor' – looks like a squirrel cage.



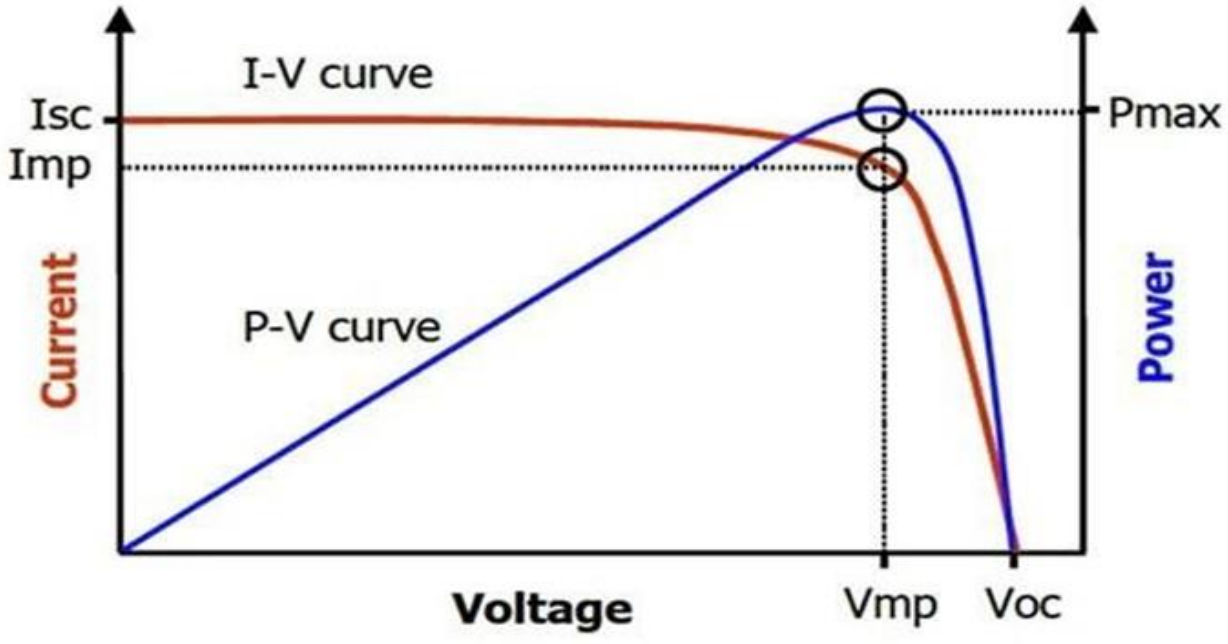
Squirrel Cage Induction Motor

When an alternating current is run through the stator windings, a rotating magnetic field is produced. This induces a current in the rotor winding, which produces its own magnetic field. The interaction of the magnetic fields produced by the stator and rotor windings produces a torque on the squirrel cage rotor.

Controlling Techniques

- ## Maximum Power Point Tracking (MPPT)

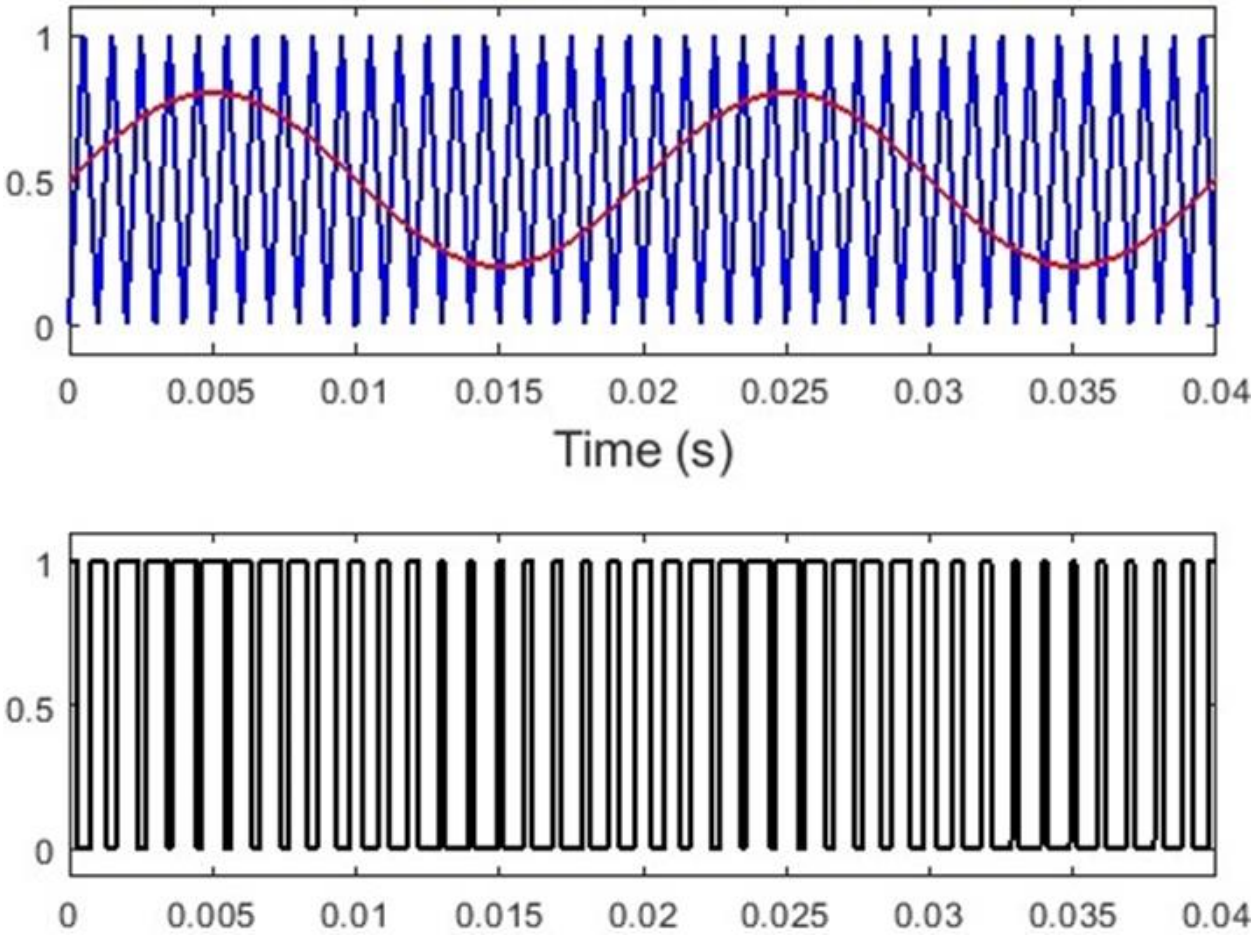
Maximum power point tracking is an algorithm which includes in charge controller. To extract maximum power from the PV array under some specific condition this algorithm is used. The voltage point at which PV panel gives maximum power is known as the maximum power point. Most extreme power delivered changes with sun powered radiation, encompassing temperature, and sun based cell temperature. The Maximum power point can be achieved by reducing the frequency in the current source region and by raising the frequency in the voltage source region.



- ## Sinusoidal Pulse-Width Modulation (SPWM) Technique

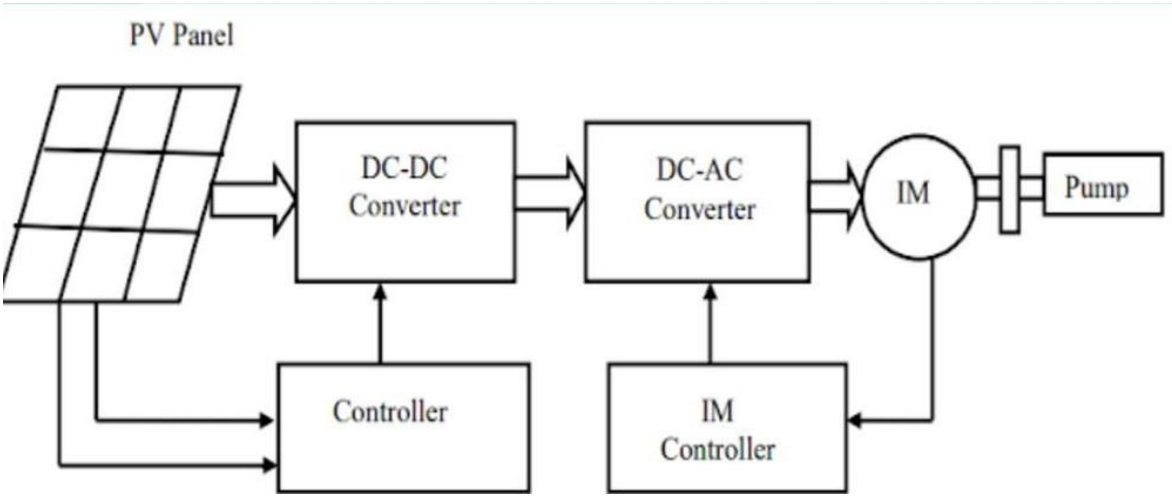
The sinusoidal pulse-width modulation (SPWM) technique produces a sinusoidal waveform by filtering an output pulse waveform with varying Width. The changes in the amplitude and frequency of the reference voltage vary the pulse width patterns of the output voltage. A low-frequency sinusoidal regulating signal is compared with a high frequency triangular signal, which

is known as the carrier signal. The exchanging state is changed when the sine waveform converges the triangular waveform. The intersection positions decide the variable switching times between states. In three-stage SPWM, a triangular voltage waveform (VT) is contrasted and three sinusoidal control voltages (V_a, V_b, and V_c), which are 120º out on stage with each other and the relative levels of the waveforms are utilized to control the exchanging of the gadgets in each stage leg of the inverter.



Design of the Proposed System

- Design of PV Pumping System



The proposed system consists of solar PV panel where the output is controlled by MPPT algorithm to extract maximum power. The output of PV panel is then fed to DC-DC boost converter which is then converted to AC output by voltage control source inverter. The output of VSI is then fed to induction motor which drives the water pump.

- Characteristics of PV Module

Parameters	Values
Rated Power	213.15 Wp
Module Efficiency	14.6%
Cell Efficiency	17%
Open Circuit Voltage(Voc)	36.3 V
Short Circuit Current(Isc)	7.84 A
Rated Voltage(Vmpp)	29 V
Rated Current(Impp)	7.35
Type of Cell	Monocrystalline

The simulation for solar panels is implemented in MATLAB. The input of 1000 irradiations are being provided to the solar PV array.

- Characteristics of Boost Converter

SPECIFICATIONS

Vinput = 250-350 V

Voutput = 650-700V

Rated power = 100KW

Switching frequency, fsw = 5KHz

Current ripple, ΔI = 5%

Voltage ripple, ΔV = 1%

Input Current = 100KW/250 = 400A

Current Ripple = 5% of 400 = 20A

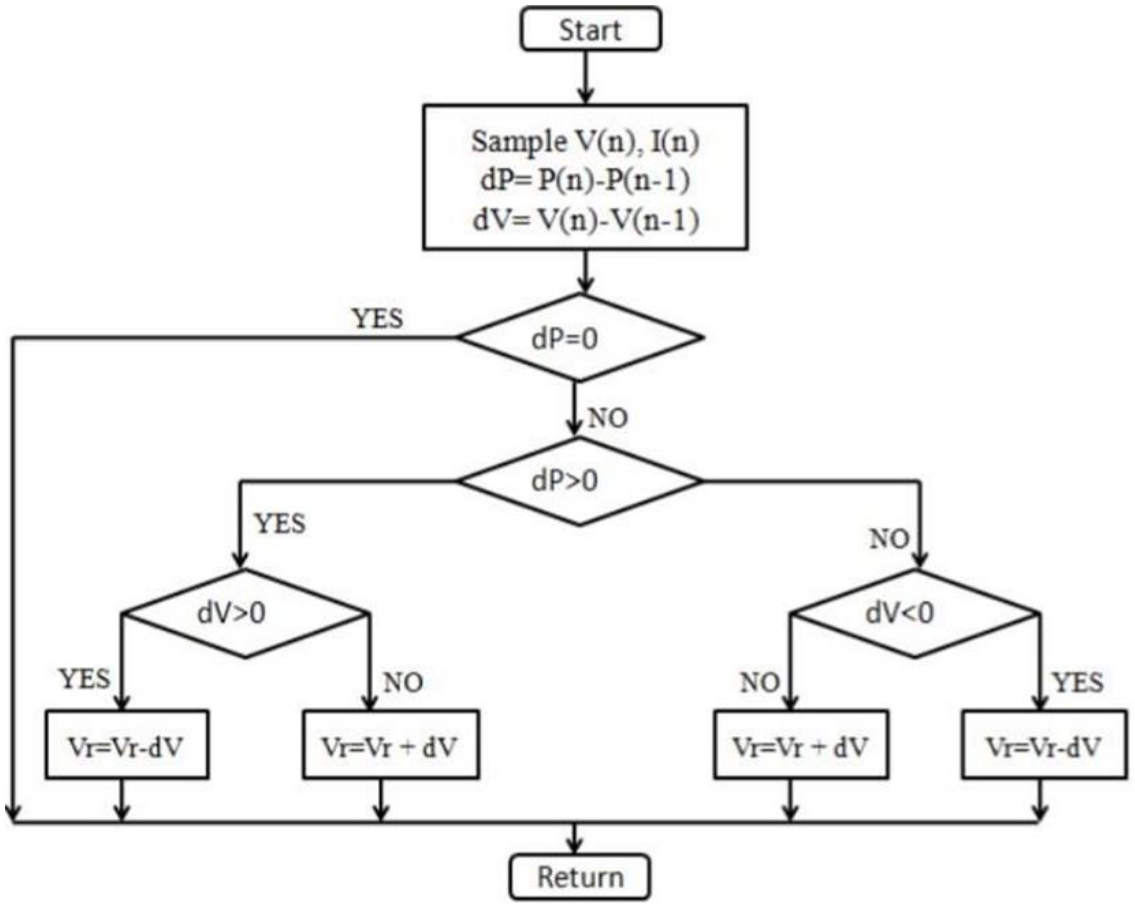
Voltage Ripple = 1% of 700 = 7V

Output Current = 100KW/700 = 142.86A

$$Inductance,\ L = \frac{Vin \cdot (Vop - Vin)}{f sw \cdot \Delta I \cdot Vop} = 1.45\ mH$$

$$Capacitance, C = \frac{Iop \cdot (Vop - Vin)}{f sw \cdot \Delta V \cdot Vop} = 3772 \mu F$$

- Flowchart of MPPT Algorithm



- Code for MPPT Algorithm

```
function Vref = RefGen(V,I)
Vrefmax = 363;
Vrefmin = 0;
Vrefinit = 300;
deltaVref = 1;
persistent Vold Pold Vrefold;
dataType = 'double';
if isempty(Vold)
```

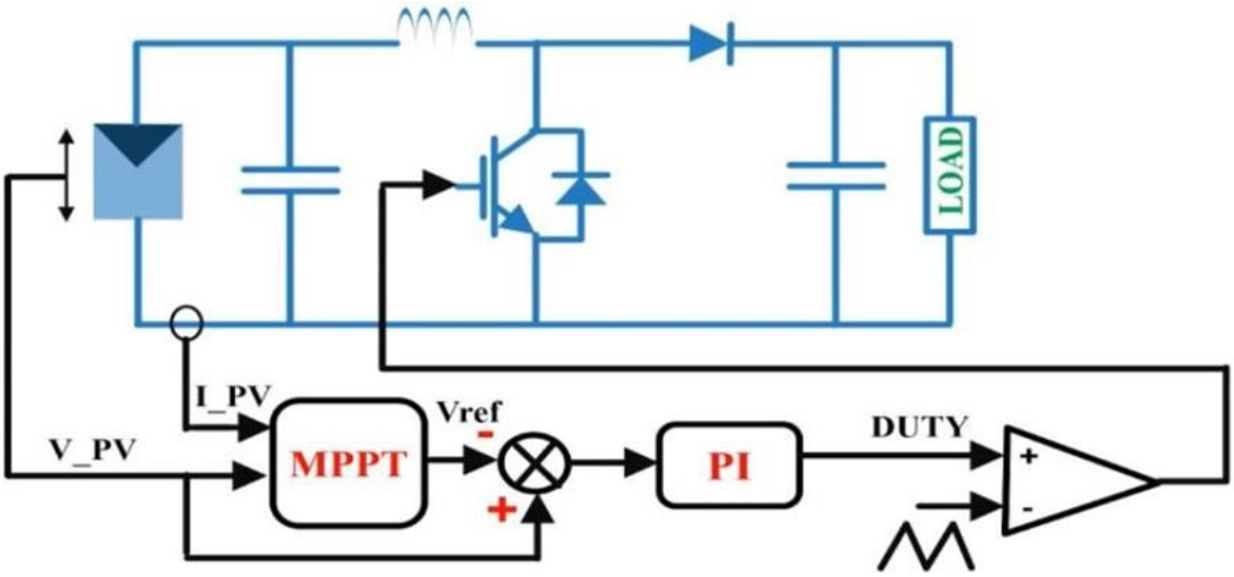
```
   Vold = 0;
   Pold = 0;
   Vrefold = Vrefinit;
end
P = V*I;
dV = V-Vold;
dP = P-Pold;
if dP~=0
   if dP<0
      if dV<0
         Vref = Vrefold + deltaVref;
      else
         Vref = Vrefold - deltaVref;
      end
   else
      if dV<0
         Vref = Vrefold - deltaVref;
      else
         Vref = Vrefold + deltaVref;
      end
   end
else Vref = Vrefold;
end

if Vref >= Vrefmax || Vref <= Vrefmin
   Vref = Vrefold;
end

Vrefold = Vref;
Vold = V;
Pold = P;
```

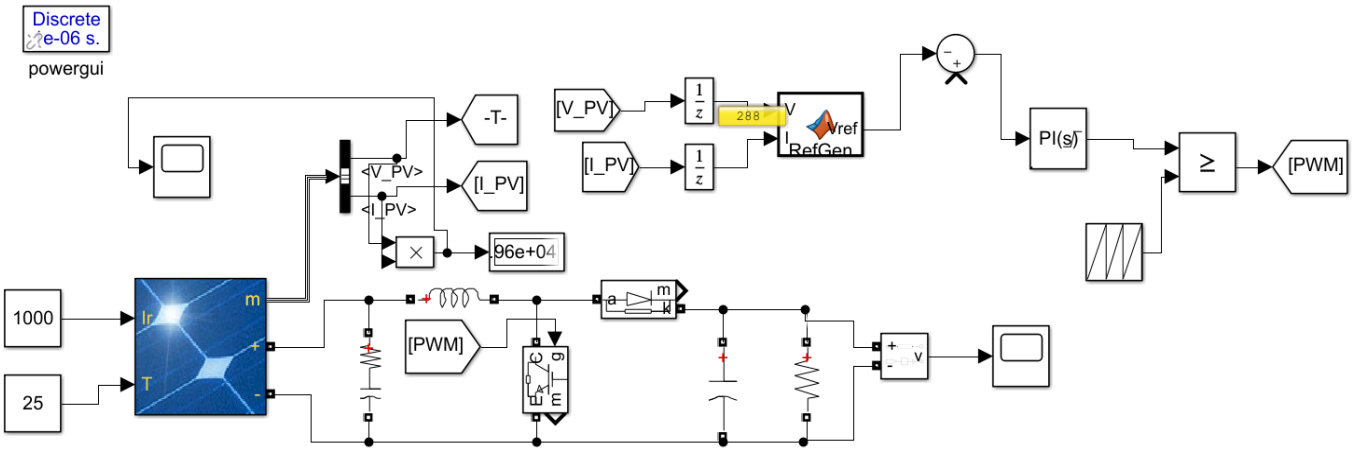
Simulation

Model for simulation

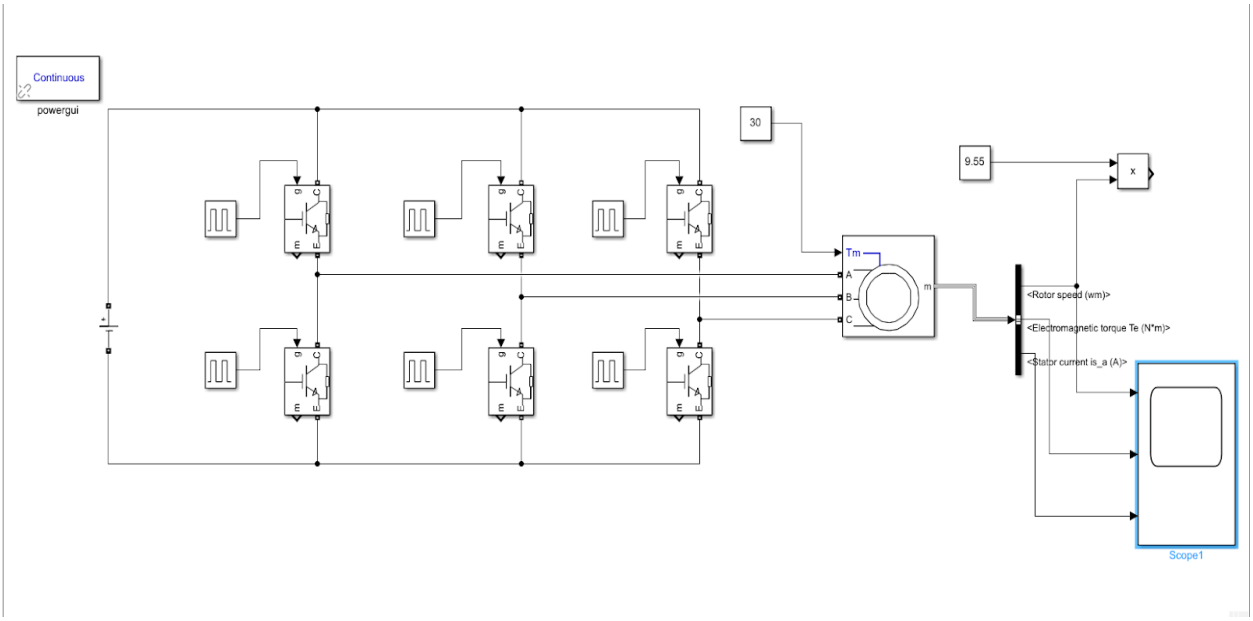


The Simulink resort comprises of Boost converter, three phase inverter and induction motor. The DC voltage received from solar cell is boosted up to the required level and then fed into three phase inverters. The voltage received from solar cell is 300V DC which is fed to boost controller. The output voltage of Boost controller is 700 V DC which will be the input to the inverter. In this model, the output of the boost converter is attached to the three-phase inverter. The PI regulator still tracks the extreme voltage of the photovoltaic array.

- Solar PV Panel with MPPT Control Technique and DC-DC Boost Converter

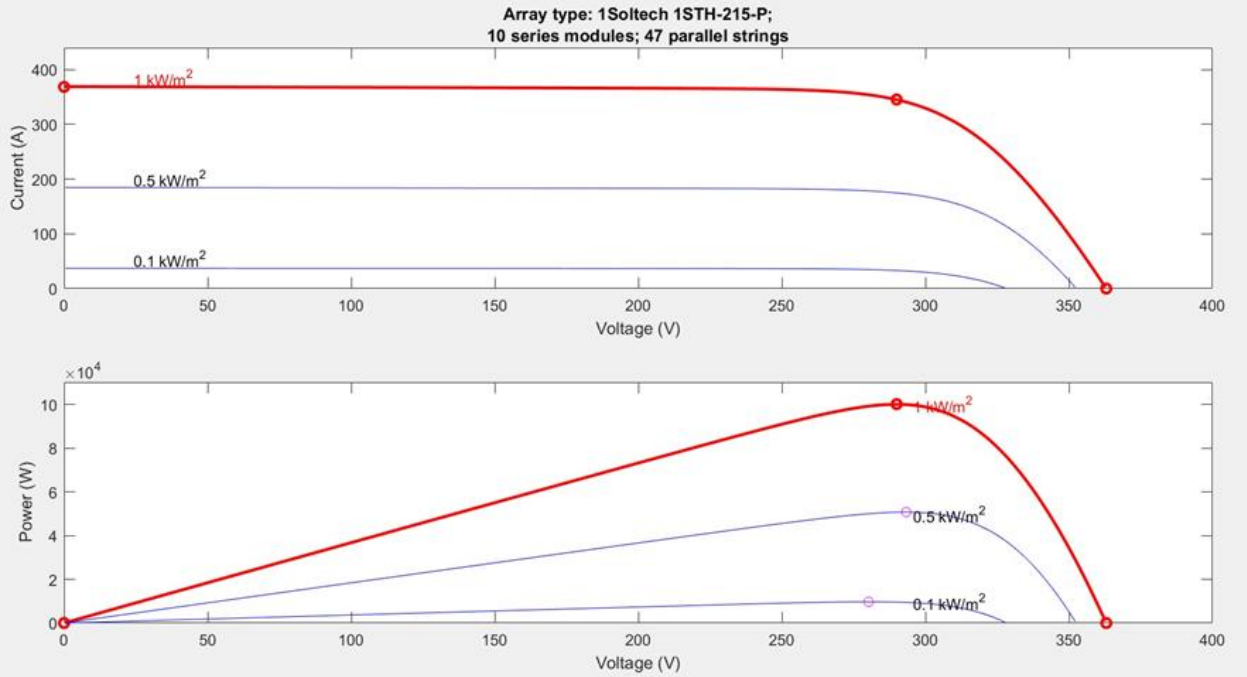


- Voltage source inverter fed induction motor

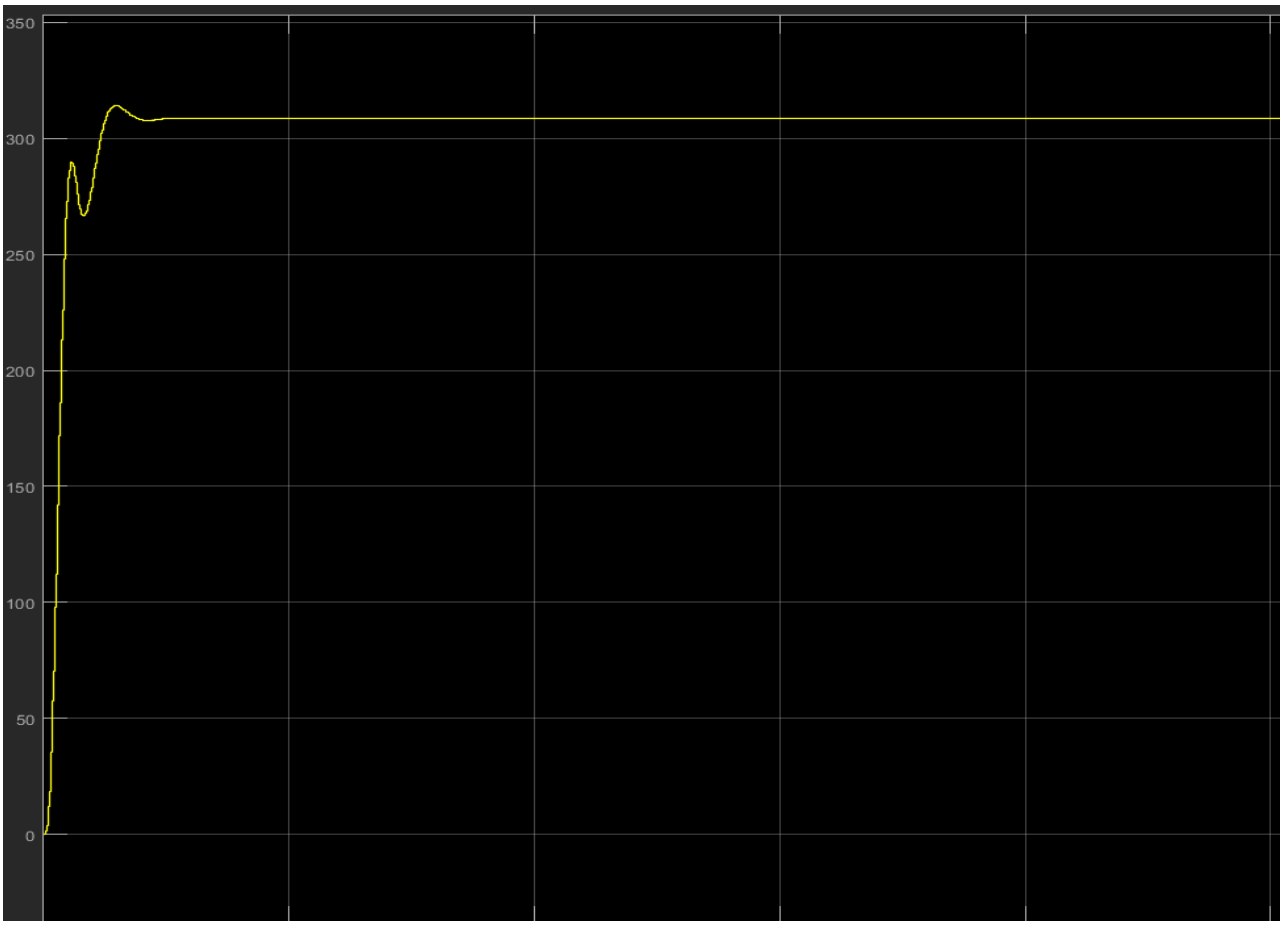


Results

- I-V and P-V plot of PV Cell

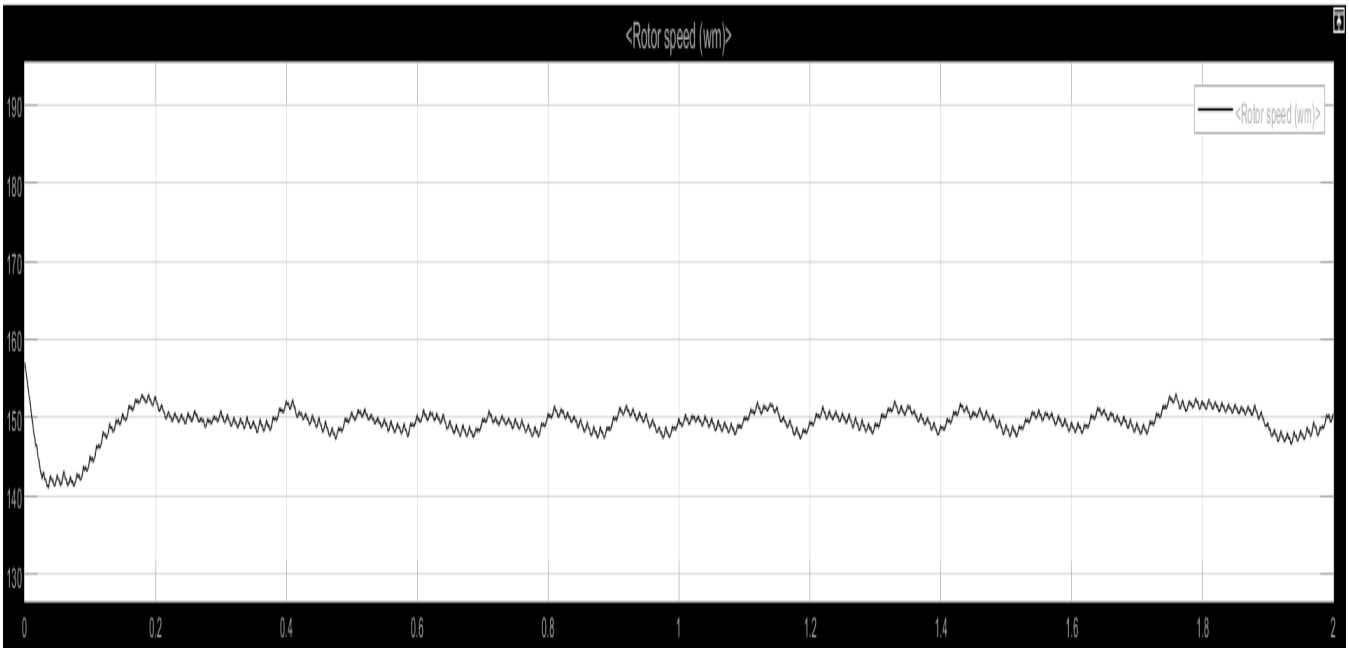


- Boost Converter Voltage

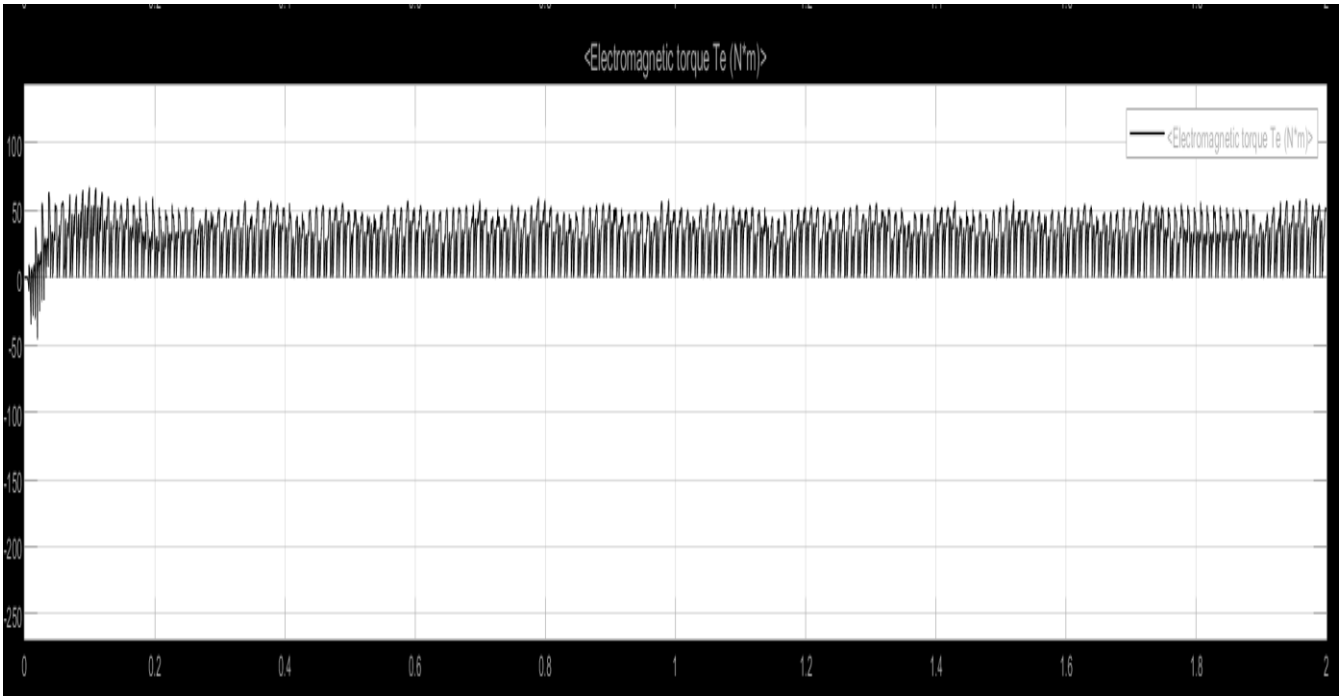


- Power Output by MPPT Algorithm

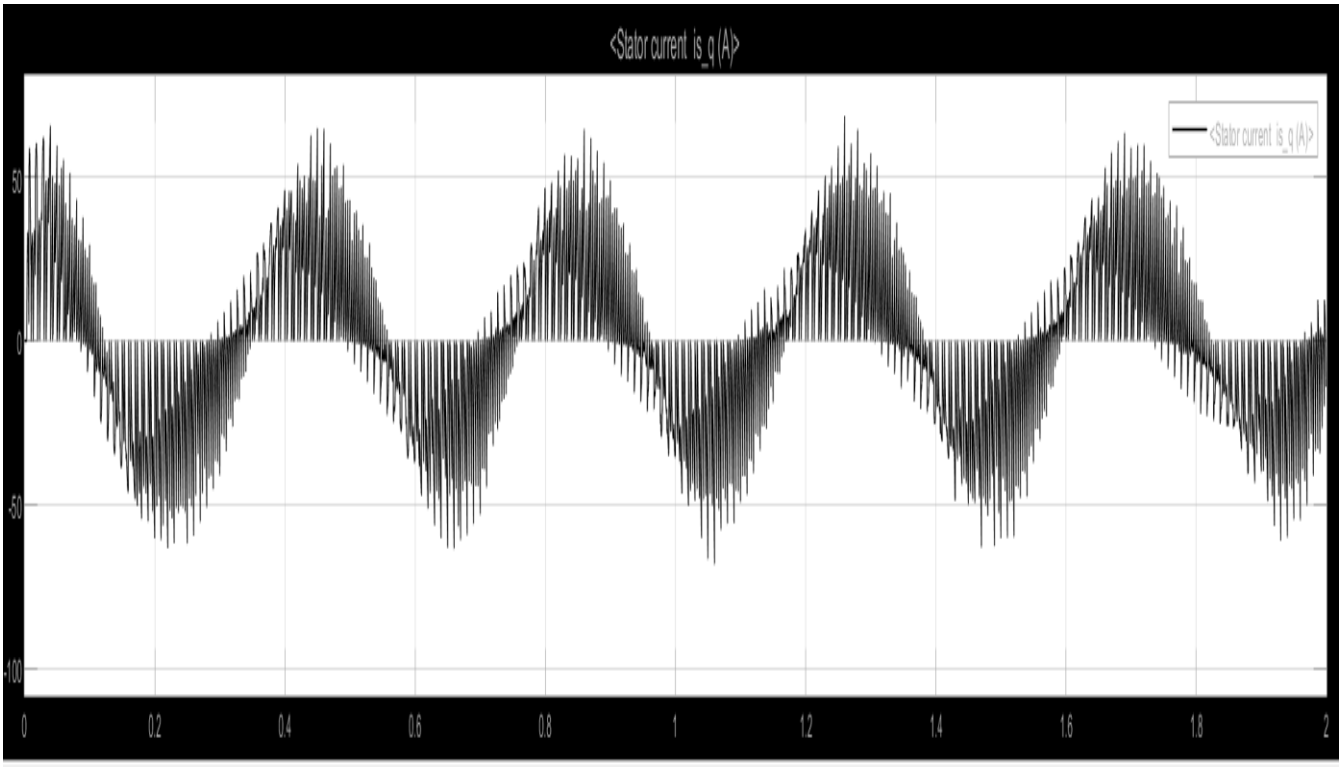
- Rotor Speed of IM in RPM



- Electromagnetic torque



- Stator Current



Conclusion

In this project, the investigation of the basic photovoltaic system has been exhibited. From the hypothesis of the photovoltaic, a PV exhibit with a band of solar irradiation level. A DC-DC converter which changes over a variable DC voltage comparing to the band of solar irradiation levels into a consistently high DC voltage. Then the reversal of this DC voltage into three phase AC voltage utilizing three phase inverter which is controlled by SW strategy has been outlined. At long last, the system has been recreated with Simulink MATLAB. In conclusion, 415 V and 2 A is obtained from the inverter and given to 3HP induction motor. The induction motor runs at 1550 rpm with constant load torque. The centrifugal pump is driven by three phase induction motors. As a future work, the hardware implementation of the boost converter with PI regulator and inverter with sinusoidal pulse width modulation will be achieved based on the MATLAB simulation.

References

1. Basic Calculation of a Boost Converter's Power Stage, SLVA372C–November 2009–Revised January 2014.
2. A. Imtiyaz, P.SathishKumar and U.Shyamaladevi, INDUCTION MOTOR DRIVEN WATER PUMP FED BY SOLAR
PHOTOVOLTAIC ARRAY USING BOOST CONVERTER,
Induction Motor Driven Water Pump Fed by Solar Photovoltaic Array Using Boost Converter, International Journal of Mechanical Engineering and Technology.
3. V T Akhila and S Arun, Review of Solar PV Powered Water
Pumping System Using Induction Motor Drive, 2018 IOP Conf. Ser.: Mater. Sci. Eng. 396 012047
4. Atul Sharma1 , Dr. Arun Parakh, DESIGN OF SOLAR POWERED
INDUCTION MOTOR DRIVE FOR PUMPING APPLICATION,
International Journal of Latest Trends in Engineering and Technology Vol.(10)Issue(1), pp.228-237.
5. Power Electronics by Muhammad H Rashid (Book)