SRM VALLIAMMAI ENGINEERING COLLEGE

(An Autonomous Institution)

SRM NAGAR, KATTANKULATHUR

DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

LAB MANUAL

M.E (POWER SYSTEMS ENGINEERING)

II Semester

PS3264 ADVANCED POWER SYSTEM SIMULATION LABORATORY

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Prepared by

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PS3264 ADVANCED POWER SYSTEM SIMULATION LABORATORY

SYLLABUS

1. Performance Characteristics of solar PV panel
2. Performance of PV panel in series and parallel combination
3. VI Characteristics of fuel cell.
4. Performance Characteristics of self – excited Induction Generator
5. Performance Characteristics of DFIG
6. Performance Characteristics of PMSG
7. MPPT tracking of DFIG based WT
8. MPPT tracking of PMSG based WT
9. Grid Integration of RES
10. Modeling of Active filter for Power system

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CYCLE – I

1. Performance Characteristics of solar PV panel
2. Performance of PV panel in series and parallel combination
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CYCLE – II

6. Performance Characteristics of PMSG
7. MPPT tracking of DFIG based WT
8. MPPT tracking of PMSG based WT
9. Grid Integration of RES
10. Modeling of Active filter for Power system

ADDITIONAL EXPERIMENTS

11. Simulation study on Hybrid (Solar-Wind) Power System.
12. Simulation study on Intelligent Controllers for Hybrid Systems.

INDEX

S.No	Date	Name of the Experiment	Marks	Signature

LIST OF EXPERIMENTAL SETUP

I CYCLE:

1. Simulation study on Solar PV Energy System.
2. Experiment on “VI-Characteristics and Efficiency of 1kWp Solar PV System”.
3. Experiment on “Shadowing effect & diode-based solution in1kWp Solar PV System”.
4. Experiment on Performance assessment of Grid connected and Standalone 1kWp Solar Power System.
5. Simulation study on Wind Energy Generator.

II CYCLE:

6. Experiment on Performance assessment of micro Wind Energy Generator.
7. Simulation study on Hybrid (Solar-Wind) Power System.
8. Experiment on Performance Assessment of Hybrid (Solar-Wind) Power System.
9. Simulation study on Hydel Power.
10. Experiment on Performance Assessment of 100W Fuel Cell.
11. Simulation study on Intelligent Controllers for Hybrid Systems

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S.No	Date	Name of the Experiment	Marks	Signature

CONTENTS

S.No	Date	Name of the Experiment	Marks	Signature
		Average Marks		

Ex.No:1

Date:

Simulation study on Solar PV Energy System

AIM:

To study PV energy system using MATLAB Simulink software.

APPARATUS REQUIRED:

S.No	Name of the Apparatus	Range	Quantity
1.	Simulation software (MATLAB Simulink)		

THEORY:

Photovoltaic (PV) power generation is a reliable and economical source of electricity in rural areas. It is important to operate the PV energy conversion systems near the maximum power point (MPP) to increase the efficiency of the PV system. But solar energy always varies instantaneously, and the current power of PV array varies non-linearly with the terminal voltage, solar radiation, and temperature. So, the maximum power output cannot be easily obtained. As solar photovoltaic cells have significant nonlinear output characteristics, the photoelectric conversion efficiency is still very low. Therefore, so far, the research of output characteristics of photovoltaic cells is an important topic in the industry. This paper proposes a mathematical model of PV array based on the principle of photovoltaic cells and establishes the simulation model in Simulink. The output characteristic curve of the photovoltaic cells is obtained with different solar radiation and temperature. Thus, it can lay the foundation for the following research of the maximum power point tracking.

PROCEDURE:

1. MATLAB Simulink model file is created.
2. Using Simulink library pv model generated.
3. Scope is verified for different values of V&I values.

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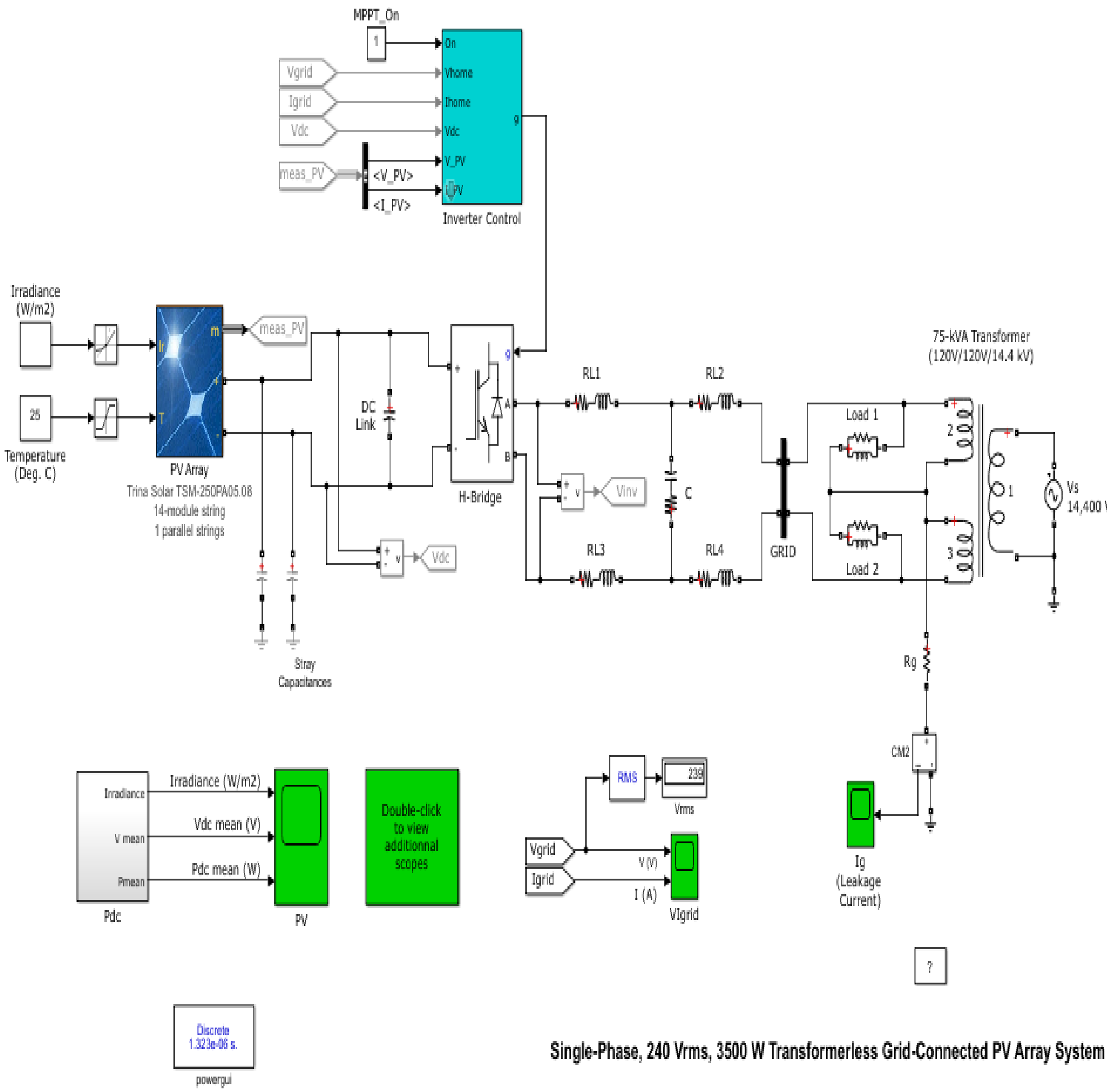
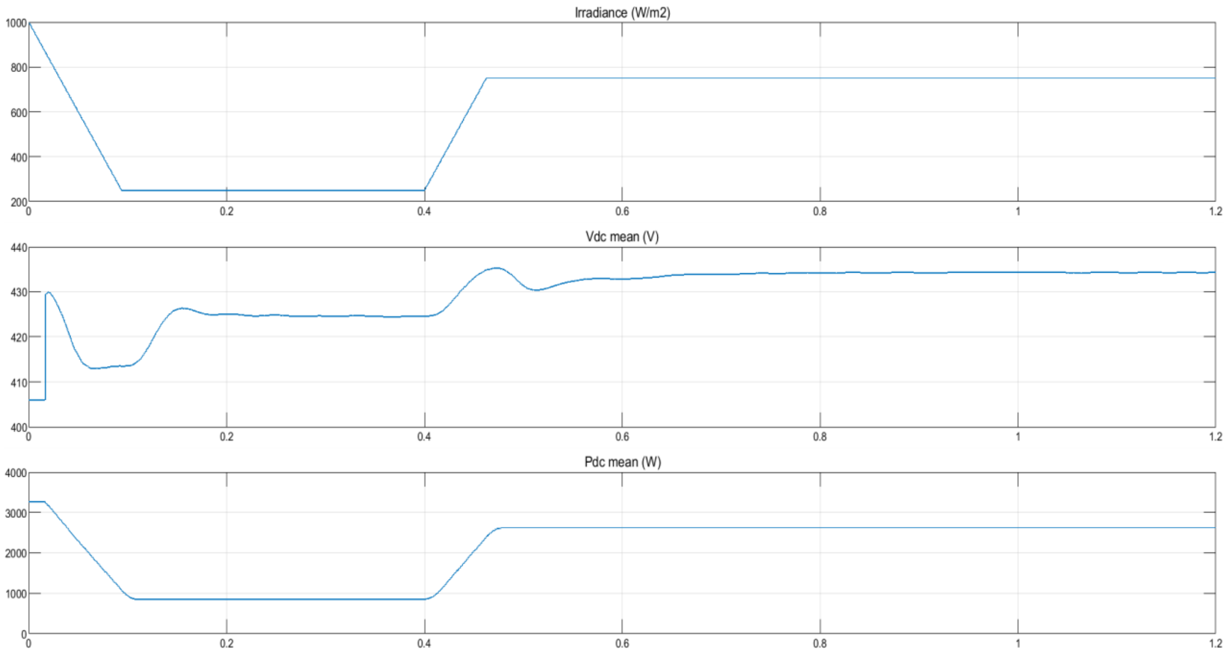
SIMULATION DIAGRAM:

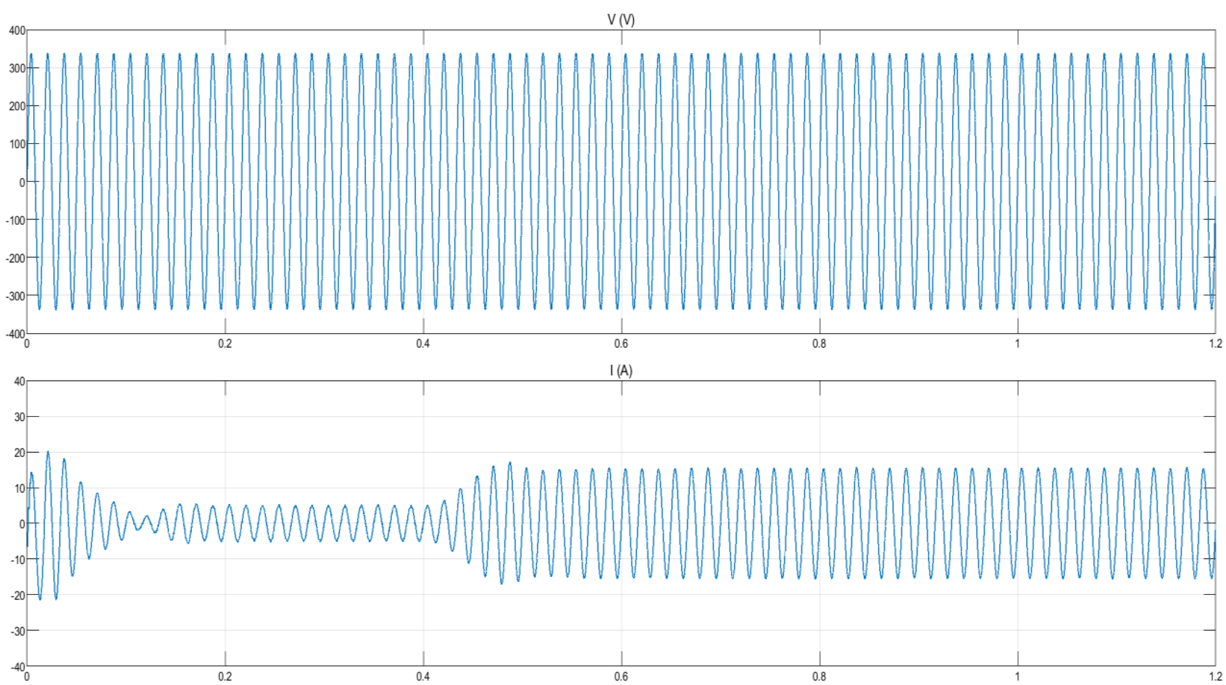


OUTPUT:

PV INPUT:



VOLTAGE AND CURRENT:



RESULT:

Thus, the study of simulation of PV systems using MATLAB Simulink model was completed.

Ex.No:2
Date:

Experiment on VI-Characteristics and Efficiency of 1kWp Solar PV System

AIM:

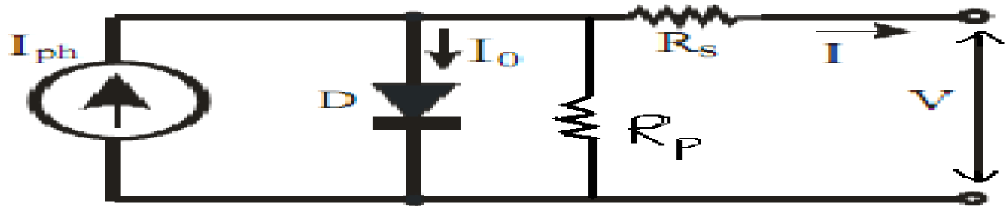
To tabulate voltage and current parameters of 1kw PV panel to study VI characteristics and efficiency.

APPARATUSREQUIRED:

S.No	Name of the Apparatus	Range	Quantity
1.	1KW PV panel		1
2.	Voltmeter	(0-300)V	1
3.	Ammeter	(0-10)A	1
4.	1KW Variable Resistor		1
5.	Connecting wires		As required

THEORY:

A material or device that can convert the energy contained in photons of light into an electrical voltage and current is said to be photo voltaic (PV). A simple equivalent circuit model for a PV cell consists of a real diode in parallel with an ideal current source. The ideal current source delivers current in proportion to the solar flux to which it is exposed. A more accurate model of a PV cell considers the effect of series and parallel resistance as shown. In a practical PV cell, there is a series resistance in a current path through the semiconductor material, the metal grid, contacts and current collecting bus. These resistive losses are lumped together as a series resistor (Rs). Similarly, a certain loss is associated with a small leakage of current through a resistive path in parallel with the intrinsic device. This can be represented by a parallel resistor (Rp). Its effect is much less conspicuous in a PV module.



Equivalent circuit of a photovoltaic cell

CIRCUITDIAGRAM:

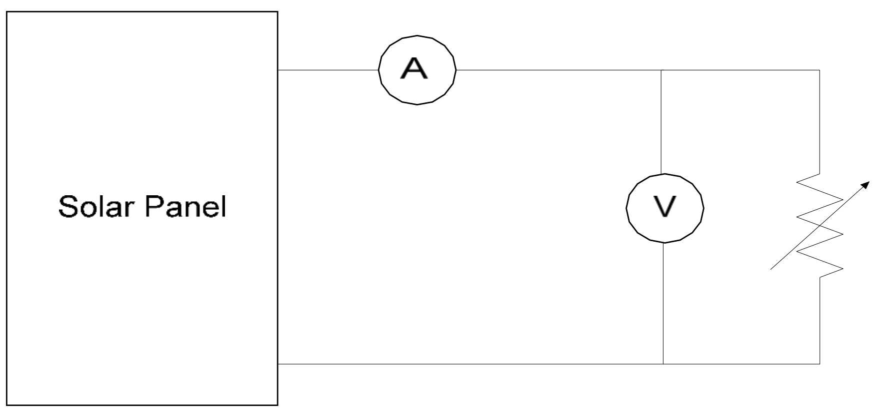
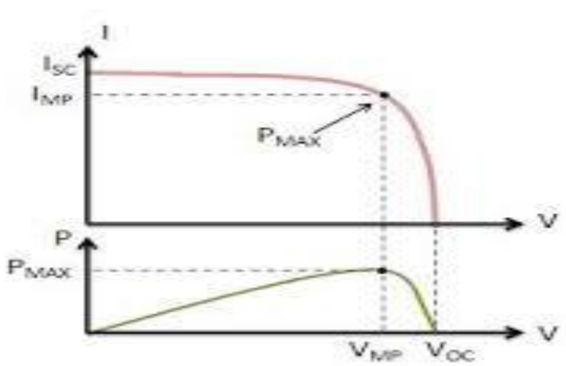


TABLE:

S.no	Voltage	Current	Power	Efficiency

PROCEDURE:

1. Choose the ammeter, voltmeter and rheostat ratings so that you get 20 uniformly spaced points on the V-I characteristics. Note that you cannot connect a single rheostat for this purpose.
2. You will need a low resistance to obtain points near the short-circuit condition, a high resistance to obtain points near the open circuit condition, and an intermediate value to obtain the maximum power point. This generally requires two or three rheostats of different ratings, with shorting switch connected across the high-resistance rheostat.
3. Vary the resistance in steps and obtain the V-I characteristics. Do NOT write down the readings to be plotted later. Plot directly while you are taking the readings. Otherwise, you will not be able to get equally spaced points on the curve.
4. Obtain the open circuit and short circuit points by opening and shorting the terminals (not by bringing the rheostat jockeys to zero position). Be very careful about getting the correct slopes at the short circuit and the open circuit points.



I-V characteristics of pv panel

RESULT:

Thus, VI parameters of 1kw PV panel were analyzed, plotted and efficiency was calculated.

Ex.No:3

Date:

Experiment on Shadowing effect & diode-based solution in 1kWp Solar PV System.

AIM:

To design diode-based solution for shadowing effect in solar PV system.

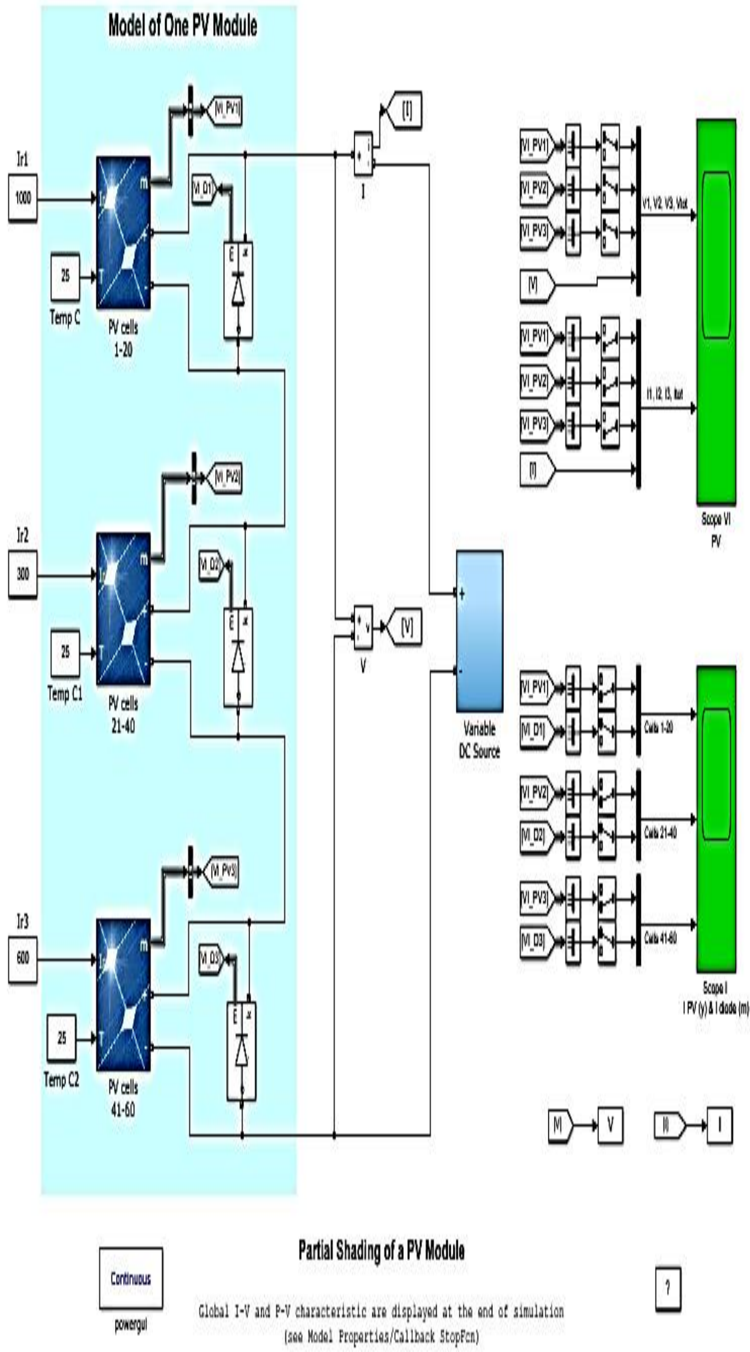
APPARATUS REQUIRED:

S. No	Name of the Apparatus	Specification	Quantity
1.	Simulation Software(MATLAB Simulink)		

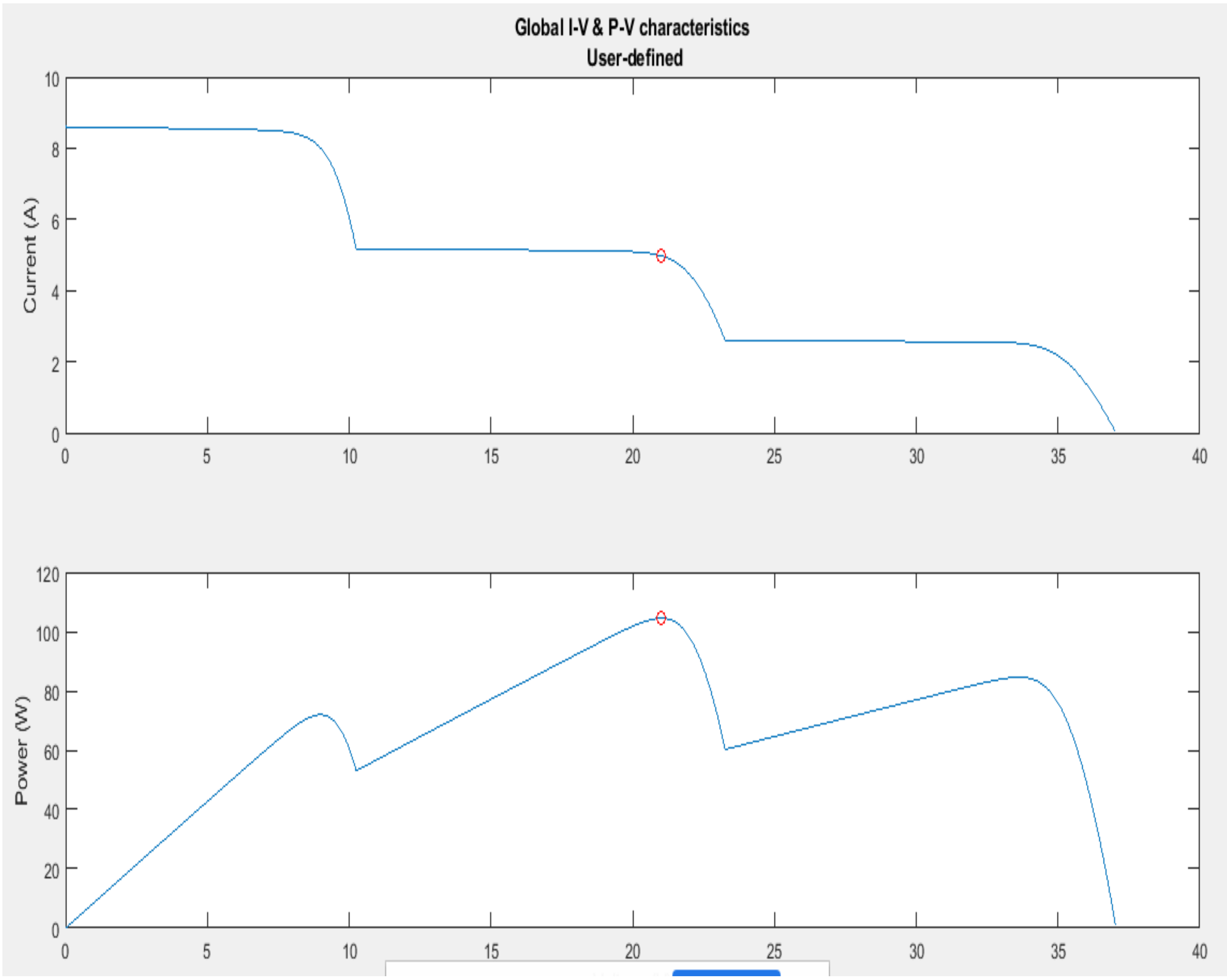
THEORY:

The global I-V and P-V characteristics are plotted at the end of simulation. Note that the P-V curve exhibits three maxima. When this PV module is connected to a voltage-sourced converter, this may be challenging for the Maximum Power Point Tracking (MPPT) algorithm to converge on the highest peak. The Global Maximum Power Point indicated by a red circle. Uniform illumination intensity in a panel is almost not satisfied because of buildings or trees shades, atmosphere fluctuation, existence of clouds and daily sun angle changes. Shade impact depends on module type, fill factor and bypass diode placement severity of shade and string configuration. Power loss occurs from shade, also current mismatch within a PV string and voltage mismatch between parallel strings.

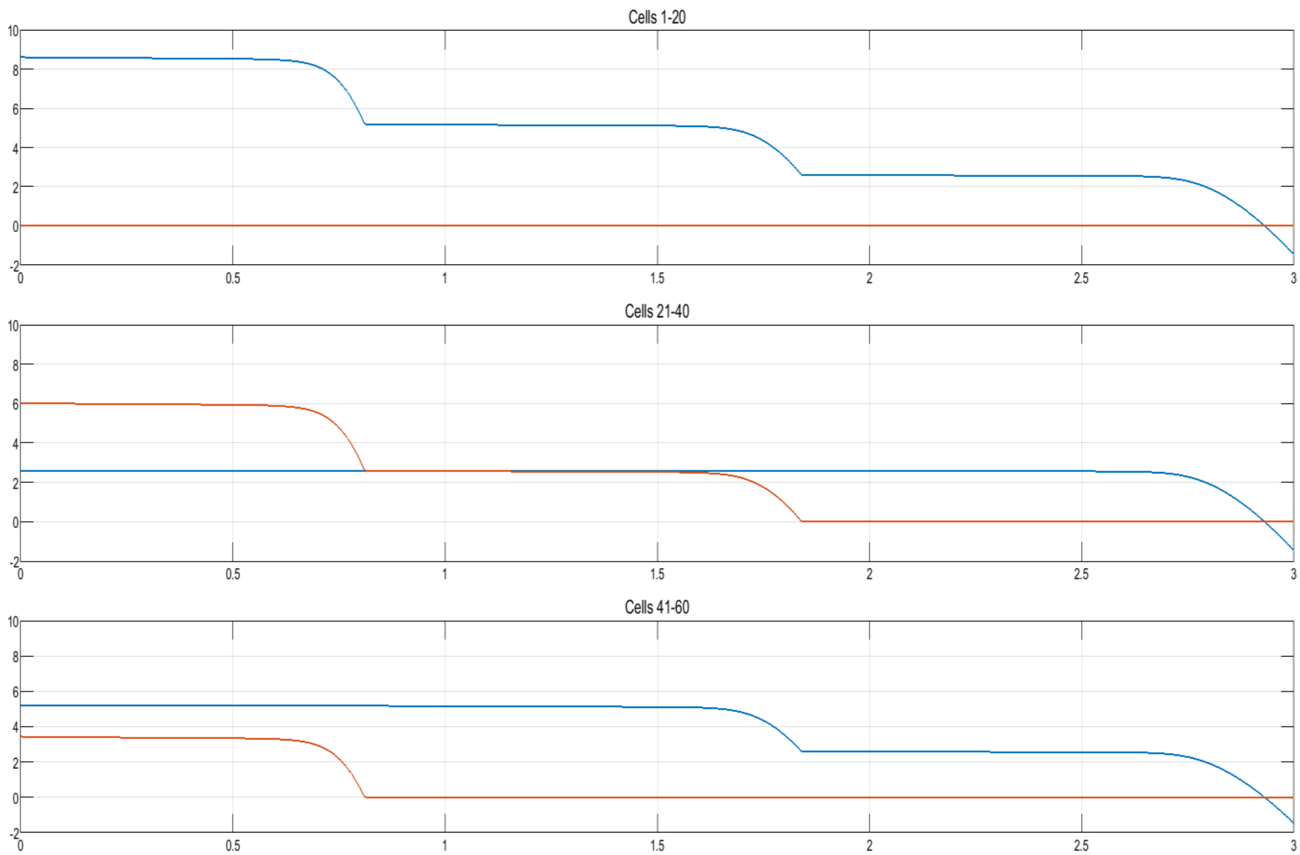
SIMULATION DIAGRAM:

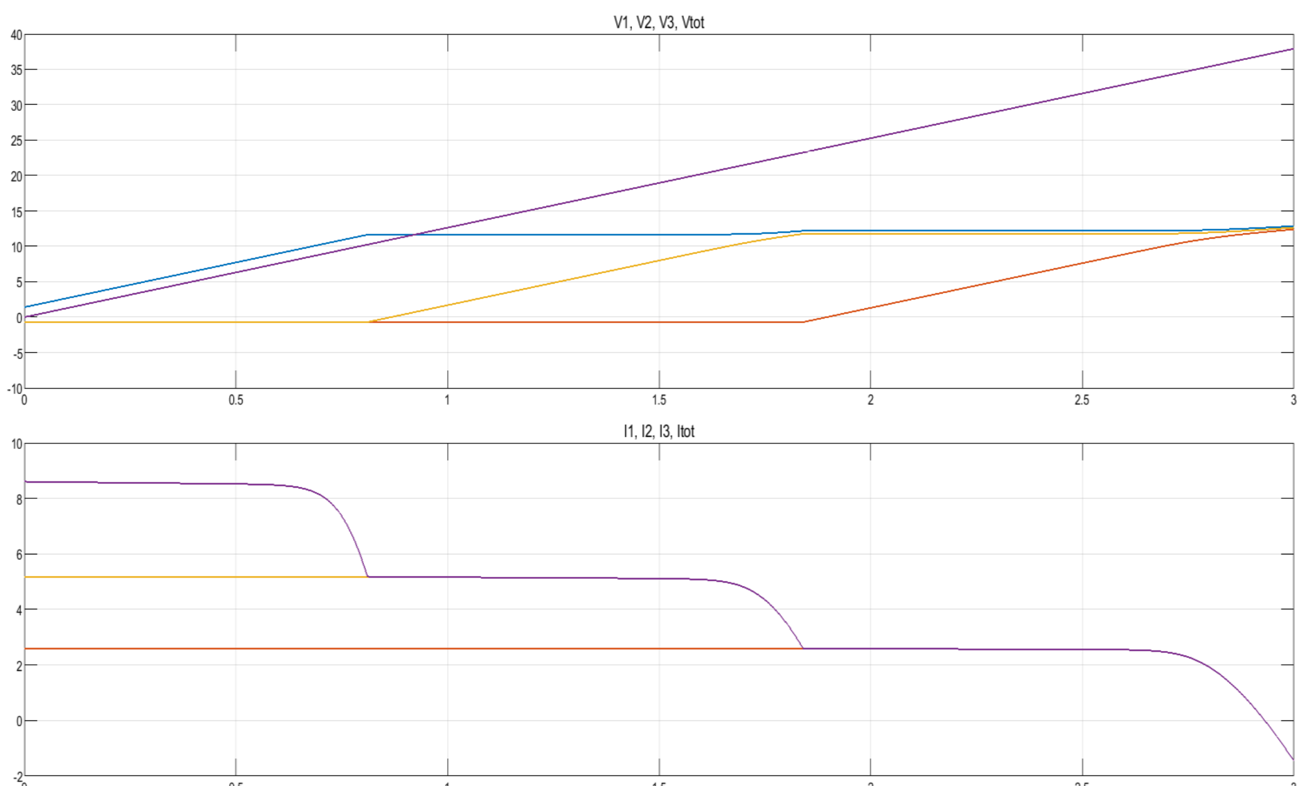


OUTPUT:



Global I-V & P-V characteristics
User-defined
Current (A)
Power (W)


Cells 1-20
Cells 21-40
Cells 41-60


V1, V2, V3, Vtot
I1, I2, I3, Itot

PROCEDURE:

1. Matlab Simulink model file is created.
2. Simulink library used to generate required components.
3. Scope is used to view results for different conditions of shadowing.

RESULT:

Thus an experiment on Shadowing effect & diode-based solution in 1kWp Solar PV system was done.

Ex. No.4

Date: **Performance Characteristics of solar PV panel**

AIM:

To conduct experiment on Performance assessment of Grid connected and Standalone 1kWp Solar Power System.

THEORY:

Standard Test Conditions (STC)

1. Temperature of the cell – 25°C. The temperature of the solar cell itself, not the temperature of
2. the surrounding.
3. Solar Irradiance – 1000 Watts per square meter. This number refers to the amount of light energy falling on a given area at a given time.
4. Mass of the air – 1.5. This number is somewhat misleading as it refers to the amount of light that must pass through Earth's atmosphere before it can hit Earth's surface and has to do mostly with the angle of the sun relative to a reference point on the earth. This number is minimized when the sun is directly above as the light has to travel a minimum distance straight down and increases as the sun goes farther from the reference point and has to go at an angle to hit the same spot.

Formula Used:

The specific energy yield is expressed in kWh per KWp and it calculated as follows:

SP =Esys / P array –STC

where

The AC energy of the solar array delivered to the grid is the Esys in the above formula

while the actual STC rating of the array is P array STC.

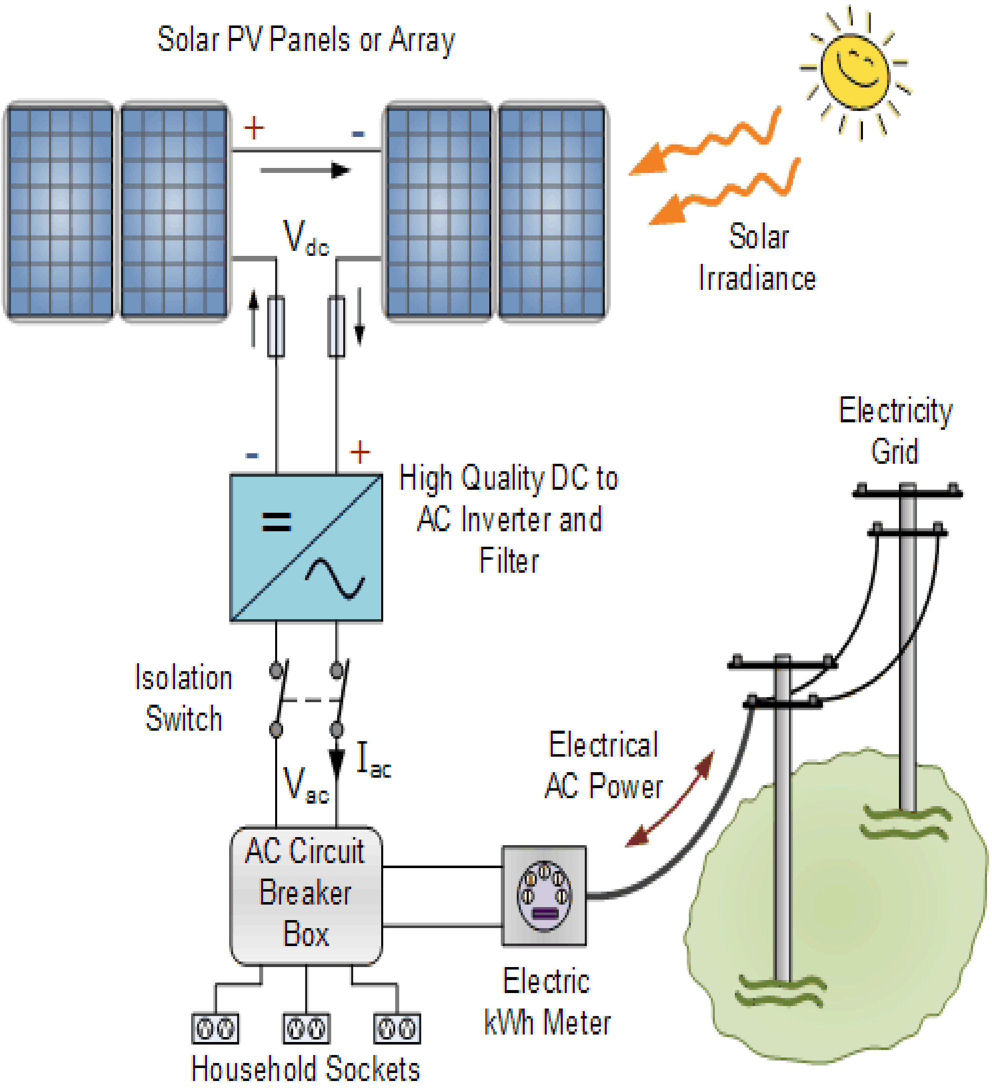
2. The performance ratio (PR)

R= E sys /E ideal

where

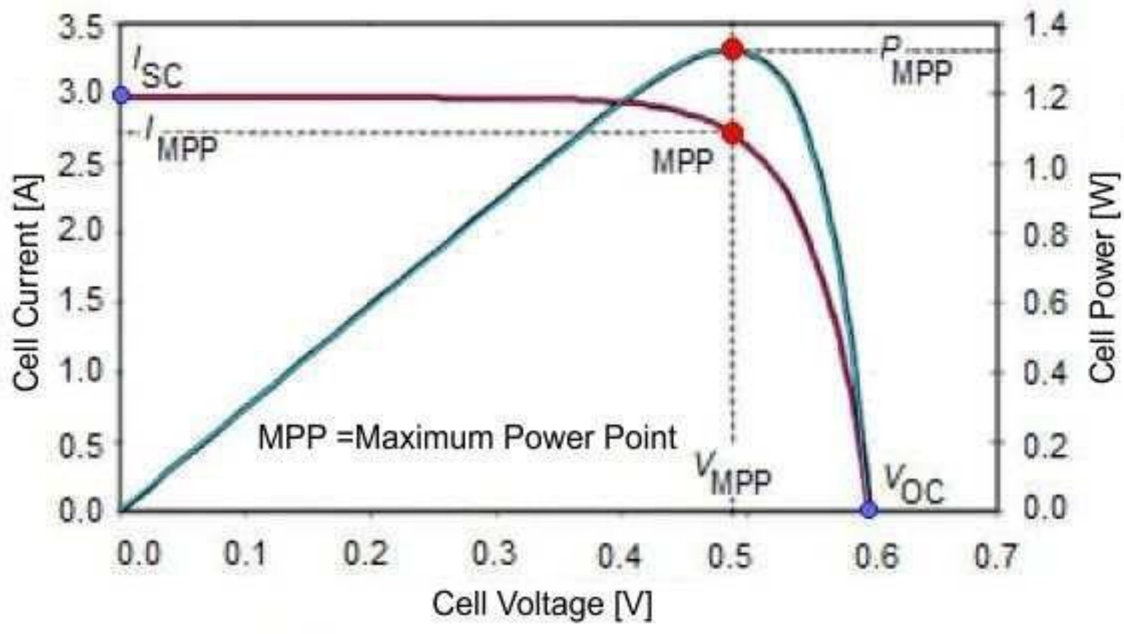
E sys - actual yearly energy yield from the system

E ideal- the ideal energy output of the array.

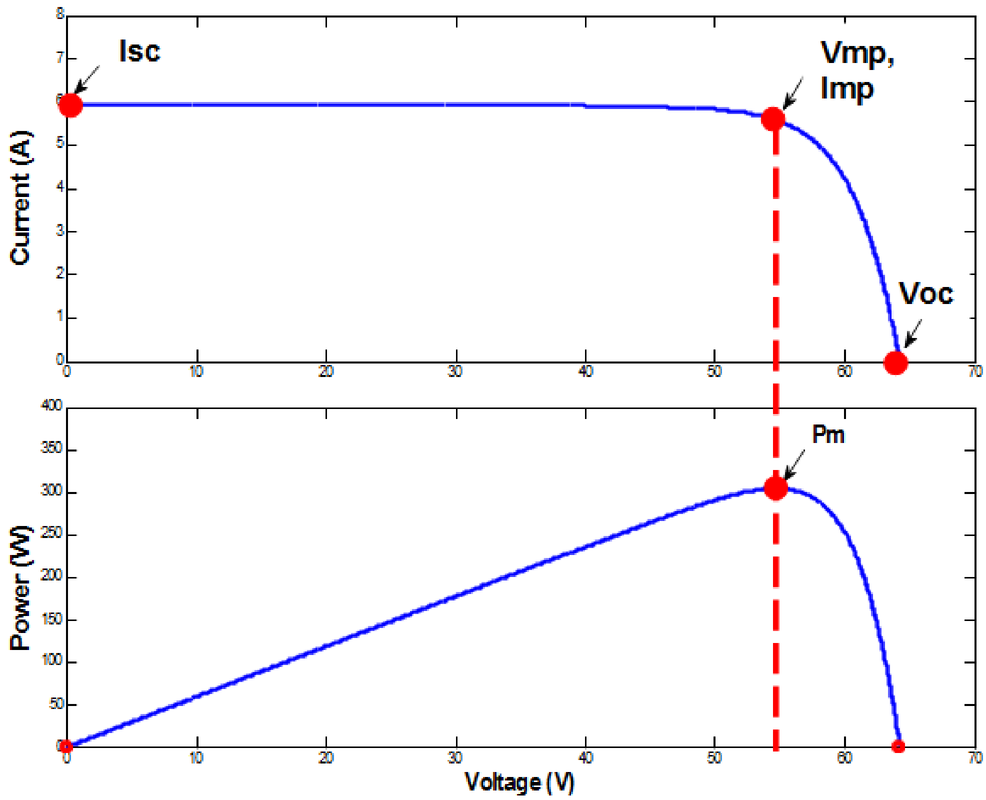


Block diagram of Grid Tied Photovoltaic Power System

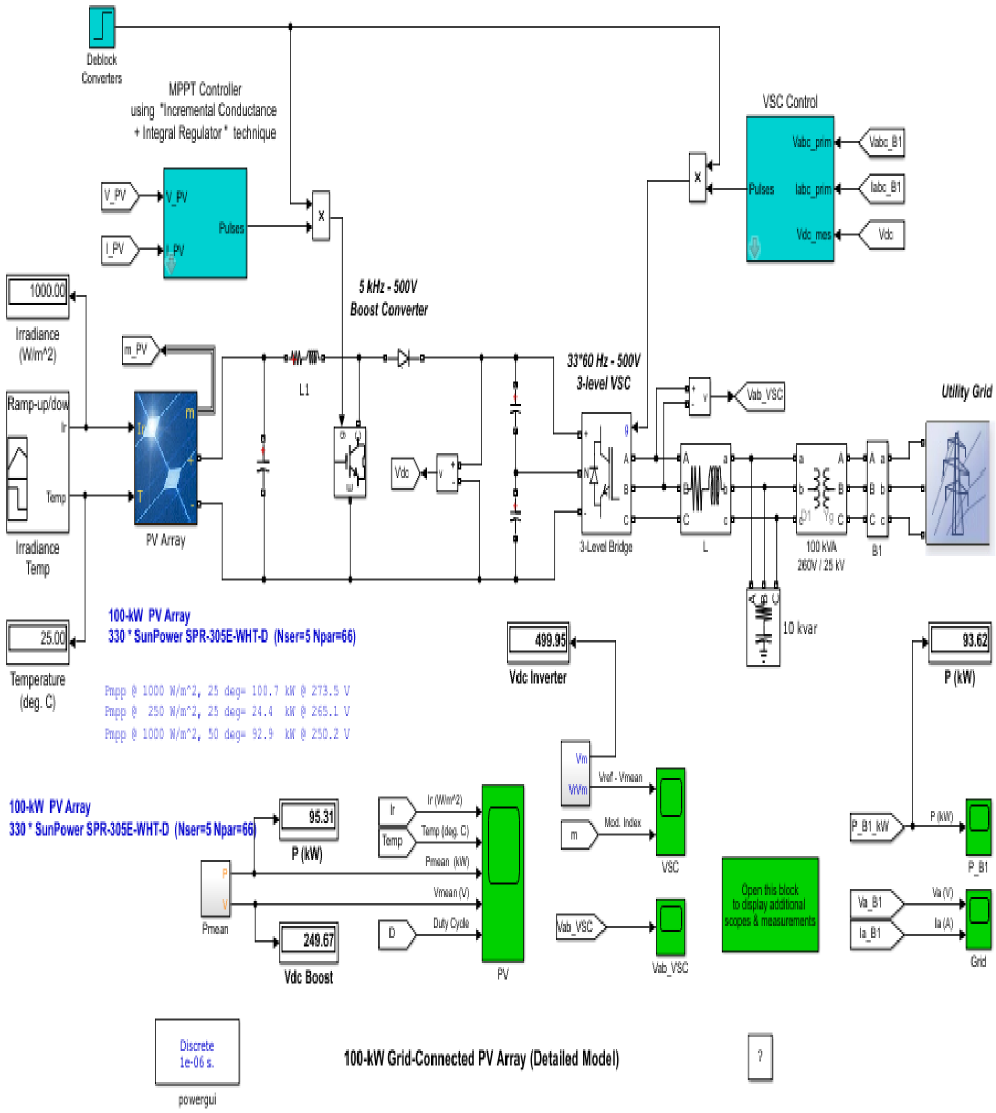
I-V Characteristics of PV System



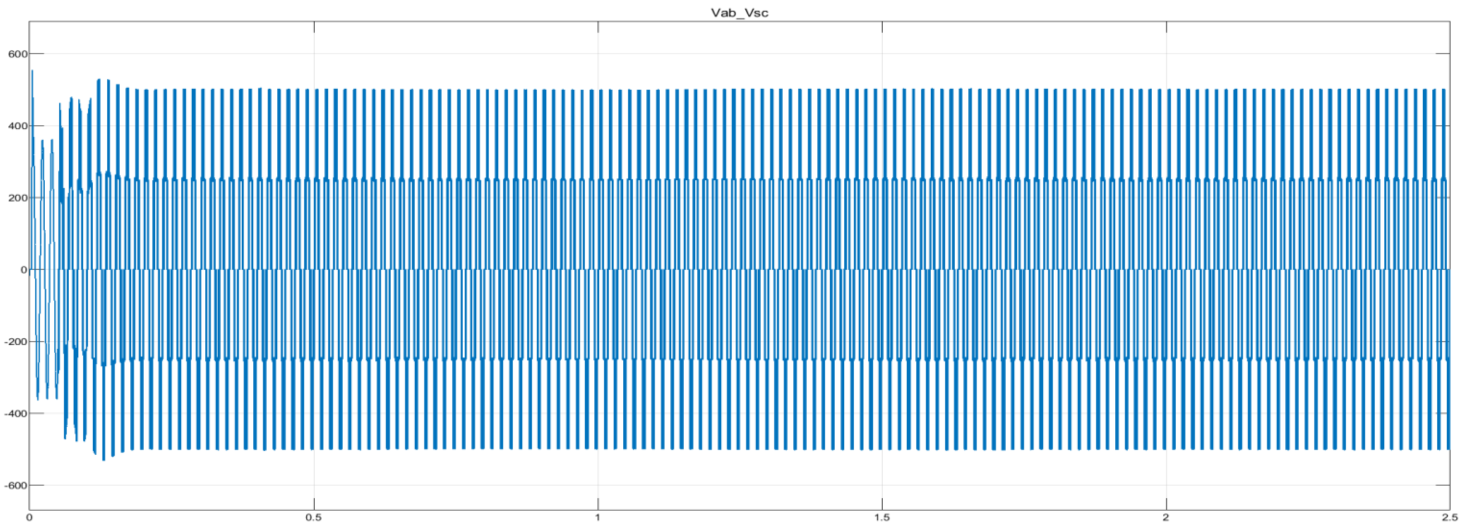
Power Vs Voltage and Current Characteristics.

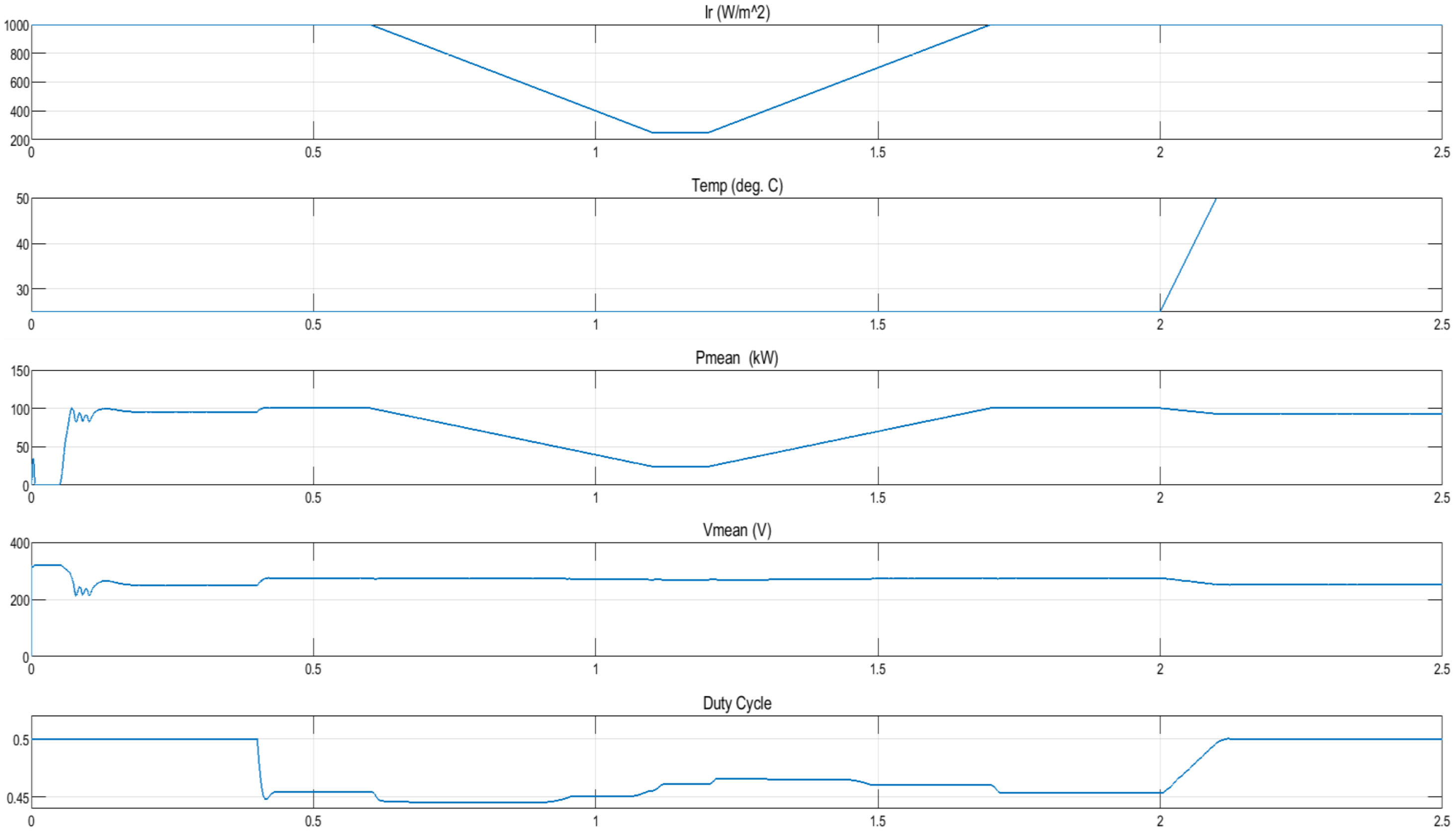


SIMULATION DIAGRAM:



OUTPUT:

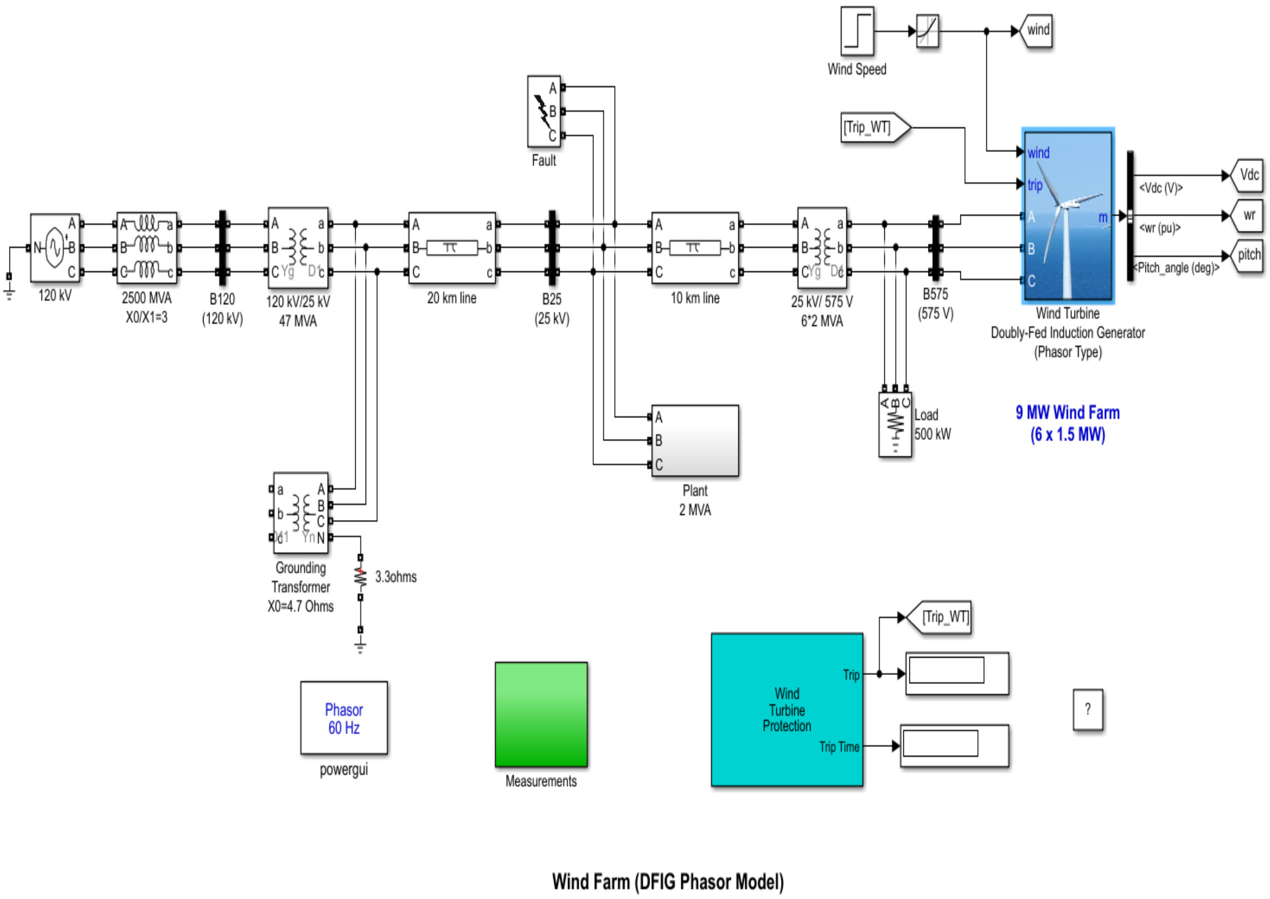




RESULT:

Thus the experiment on performance assessment of grid connected and standalone 1kWp solar power system was performed using MATLAB simulink.

CIRCUIT DIAGRAM:



Wind Turbine Simulation Block diagram

Ex. No.5
Date:

Simulation study on Wind Energy Generator

AIM:

To conduct the Simulation and study on Wind Energy Generator

APPARATUS REQUIRED:

S.No.	APPARATUS	RANGE	TYPE	QUANTITY
1	Matlab Simulink			1

THEORY:

Wind turbines work on a simple principle: instead of using electricity to make wind—like a fan wind turbines use wind to make electricity. Wind turns the propeller-like blades of a turbine around a rotor, which spins a generator, which creates electricity.

Wind is a form of solar energy caused by a combination of three concurrent events: The sun unevenly heating the atmosphere, Irregularities of the earth's surface and the rotation of the earthThe terms "wind energy" and "wind power" both describe the process by which the wind is used to generate mechanical power or electricity. This mechanical power can be used for specific tasks (such as grinding grain or pumping water) or a generator can convert this mechanical power into electricity. A wind turbine turns wind energy into electricity using the aerodynamic force from the rotor blades, which work like an airplane wing or helicopter rotor blade. When wind flows across the blade, the air pressure on one side of the blade decreases. The difference in air pressure across the two sides of the blade creates both lift and drag. The force of the lift is stronger than the drag and this causes the rotor to spin. The rotor connects to the generator, either directly (if it's a direct drive turbine) or through a shaft and a series of gears (a gearbox) that speed up the rotation and allow for a physically smaller generator. This translation of aerodynamic force to rotation of a generator creates electricity.

FORMULA:

Power (W) = 0.6 x Cp x N x A x V3 .

Revolutions (rpm) = V x TSR x 60 / (6.28 x R),

Where

Cp = Rotor efficiency,

N = Efficiency of driven machinery,

A = Swept rotor area (m2),

V = Wind speed (m/s)

TSR = Tip Speed Ratio,

R = Radius of rotor, Rotor efficiency can go as high as Cp = 0.48, but Cp = 0.4

Simulation Methods of the DFIG

A 9-MW wind farm consisting of six 1.5 MW wind turbines connected to a 25-kV distribution system exports power to a 120-kV grid through a 30-km, 25-kV feeder. A 2300V, 2-MVA plant consisting of a motor load (1.68 MW induction motor at 0.93 PF) and of a 200-kW resistive load is connected on the same feeder at bus B25. Both the wind turbine and the motor load have a protection system monitoring voltage, current and machine speed. The DC link voltage of the DFIG is also monitored.

Wind turbines use a doubly fed induction generator (DFIG) consisting of a wound rotor induction generator and an AC/DC/AC IGBT-based PWM converter. The stator winding is connected directly to the 60 Hz grid while the rotor is fed at variable frequency through the AC/DC/AC converter. DFIG technology allows extracting maximum energy from the wind for low wind speeds by optimizing the turbine speed, while minimizing mechanical stresses on the turbine during gusts of wind. The optimum turbine speed producing maximum mechanical energy for a given wind speed is proportional to the wind speed. For wind speeds lower than 10 m/s the rotor is running at sub synchronous speed. At high wind speed it is running at hypersynchronous speed. Open the turbine menu, select "Turbine data" and check "Display wind-turbine power characteristics". The turbine mechanical power as function of turbine speed is displayed for wind speeds ranging from 5 m/s to 16.2 m/s. The DFIG is controlled to follow the red curve. Turbine speed optimization is obtained between point B and point C on this curve. Another advantage of DFIG technology is the ability for power electronic converters to generate or absorb reactive power, thus eliminating the need for installing capacitor banks as in the case of squirrel-cage induction generators.

The wind-turbine model is a phasor model that allows transient stability type studies with long simulation times. In this example, the system is observed during 50 s.Open the wind turbine block menu and look at the four sets of parameters specified for the turbine, the generator and the converters (grid-side and rotor-side). The 6-wind-turbine farm is simulated by a single wind-turbine block by multiplying the following three parameters by six, as follows:

1. The nominal wind turbine mechanical output: 6*1.5e6 watts, specified in the Turbine data menu

2. The generator rated power: 6*1.5/0.9 MVA (6*1.5 MW at 0.9 PF), specified in the Generator data menu

3. The nominal DC bus capacitor: 6*10000 micro farads, specified in the Converters data menu

Also, notice in the Control parameters menu that the "Mode of operation" is set to " Voltage regulation". The terminal voltage will be controlled to a value imposed by the reference voltage (Vref = 1 pu) and the voltage droop (Xs = 0.02 pu).

Description

A 9 MW wind farm consisting of six 1.5 MW wind turbines connected to a 25 kV distribution system exports power to a 120 kV grid through a 30 km, 25 kV feeder.Wind turbines using a doubly-fed induction generator (DFIG) consist of a wound rotor induction generator and an AC/DC/AC IGBT-based PWM converter. The stator winding is connected directly to the 60 Hz grid while the rotor is fed at variable frequency through the AC/DC/AC converter. DFIG technology allows extracting maximum energy from the wind for low wind speeds by optimizing the turbine speed, while minimizing mechanical stresses on the turbine during gusts of wind.

In this example the wind speed is maintained constant at 15 m/s. The control system uses a torque controller to maintain the speed at 1.2 pu. The reactive power produced by the wind turbine is regulated at 0 Mvar.

Right-click on the "DFIG wind Turbine" block and select "Look Under Mask" to see how the model is built. The sample time used to discretize the model (Ts= 50 microseconds) is specified in the Initialization function of the Model Properties.

Open the "DFIG wind Turbine" block menu to see the data of the generator, the converter, the turbine, the drive train and the control systems. In the Display menu select "Turbine data for 1 wind turbine", check "Display wind turbine power characteristics" and then click apply. The turbine Cp curves are displayed in Figure 1. The turbine power, the tip speed ratio lambda and the Cp values are displayed in Figure 2 as a function of wind speed. For a wind speed of 15 m/s, the turbine output power is 1 pu of its rated power, the pitch angle is 8.7 deg and the generator speed is 1.2 pu.

Simulation

In this example you will observe the steady-state operation of the DFIG and its dynamic response to voltage sag resulting from a remote fault on the 120-kV system. Open the "120 kV" block modeling the voltage source and see how a six-cycle 0.5 pu voltage drop is programmed at t=0.03 s

Start simulation. Observe voltage and current waveforms on the Scope block. At simulation start the "xInitial" variable containing the initial state variables is automatically loaded (from the "power_wind_dfig_det.mat" file specified in the Model Properties) so that the simulation starts in steady state.

Initially the DFIG wind farm produces 9 MW. The corresponding turbine speed is 1.2 pu of generator synchronous speed. The DC voltage is regulated at 1150 V and reactive power is kept at 0 Mvar. At t=0.03 s the positive-sequence voltage suddenly drops to 0.5 p.u. causing an oscillation on the DC bus voltage and on the DFIG output power. During the voltage sag the control system tries to regulate DC voltage and reactive power at their set points (1150 V, 0 Mvar). The system recovers in approximately 4 cycles.

Regenerate Initial Conditions

This example is set-up with all states initialized so that the simulation starts in a steady state. Otherwise, due to the long-time constants of the electromechanical part of the wind turbine model and to its relatively slow regulators you would have to wait for tens of seconds before reaching steady state. The initial conditions have been saved in the "power_wind_dfig_det.mat" file. When you start simulation, the InitFcn callback (in the Model Properties/Callbacks) automatically loads into your workspace the contents of this .mat file ("xInitial" variable specified in the "Initial state" parameter in the Simulation/Configuration Parameters menu).

If you modify this model, or change parameter values of power components, the initial conditions stored in the "xInitial" variable will no longer be valid and Simulink® will issue an error message.

To regenerate the initial conditions for your modified model, follow the steps listed below:

1. In the Simulation/Configuration Parameters menu, uncheck the "Initial state" parameter.

2. In the 120 kV Three-phase Voltage Source menu, disable the source voltage step by setting the "Time variation of" parameter to "none".

3. To shorten the time required to reach steady-state, you will have to temporarily decrease the inertia of the turbine-generator group. Open the DFIG Wind Turbine menu and in the Drive train data and Generator data, divide the H inertia constants by 10.

4. Change the Simulation Stop Time to 5 seconds. Note that to generate initial conditions coherent with the 60 Hz voltage source phase angles, the Stop Time must be an integer number of 60 Hz cycles.

5. Change the Simulation Mode from "Normal" to "Accelerator".

6. Start simulation. When the Simulation is completed, verify that steady state has been reached by looking at waveforms displayed on the Scope block. The final states which have been saved in the "xFinal" structure with time can be used as initial states for future simulations. Executing the next two commands copies these final conditions in "xInitial" and saves this variable in a new file (myModel_init.mat). * >> xInitial=xFinal; * >> save myModel_init xInitial

7. In the File/Model Properties/Callbacks/InitFcn window, replace the first line of initialization commands with "load myModel_init". Next time you start a simulation with this model, the variable xInitial saved in the myModel_init.mat file will be loaded in your workspace.

8. In the Simulation/Configuration Parameters menu, check "Initial state".

9. In the Wind Turbine Generator and Drive train data, reset the inertia constants H back to their original values.

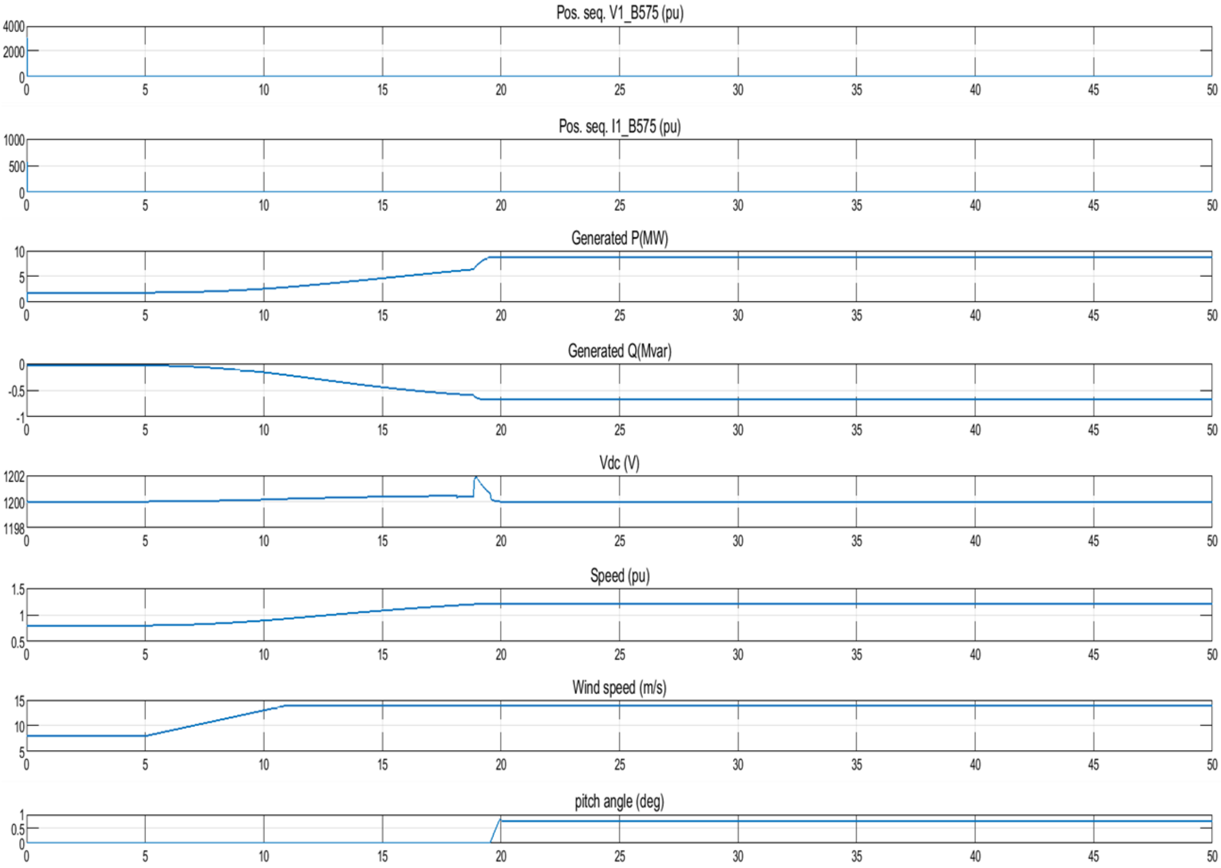
10. Start simulation and verify that your model starts in steady state.

11. In the 120 kV Three-phase voltage source menu, set the "Time variation of" parameter back to "Amplitude".

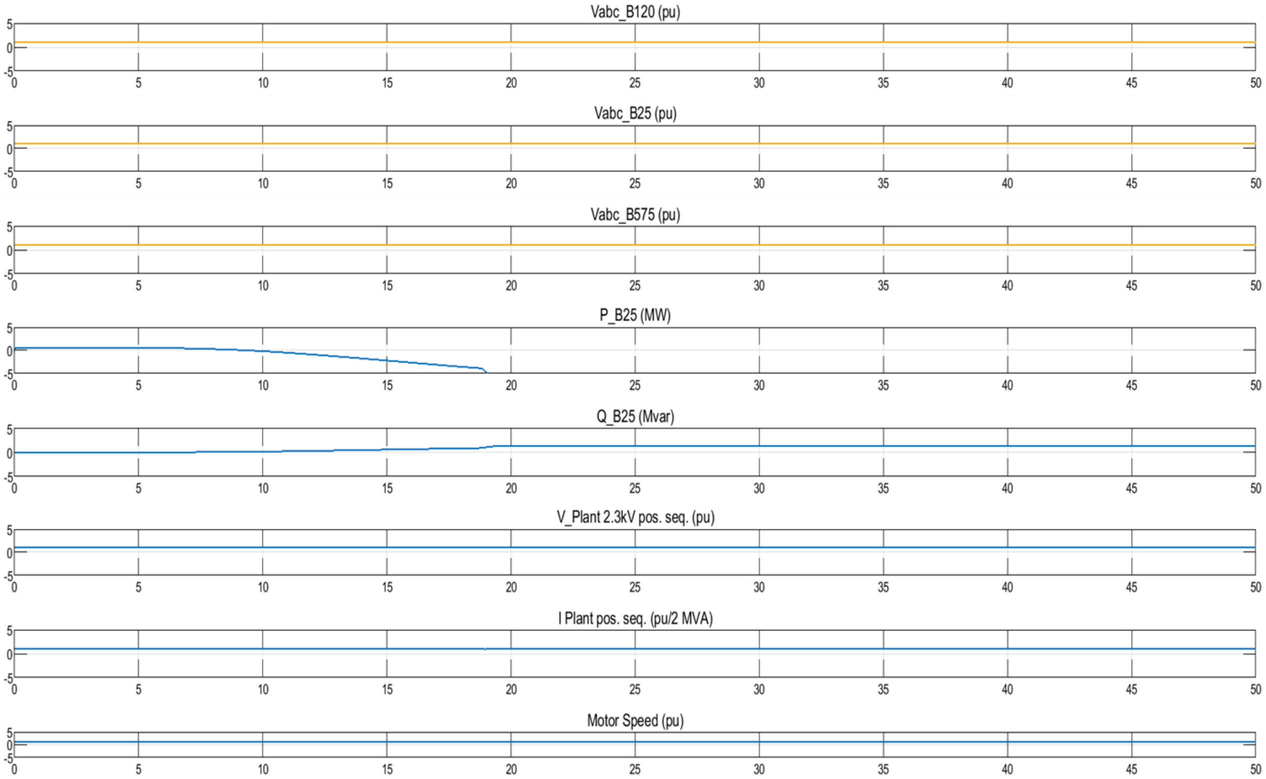
12. Change the Simulation Stop Time and Simulation Mode back to their original values (0.2 seconds, Normal).

13. Save your Model.

WIND TURBINE INPUT:



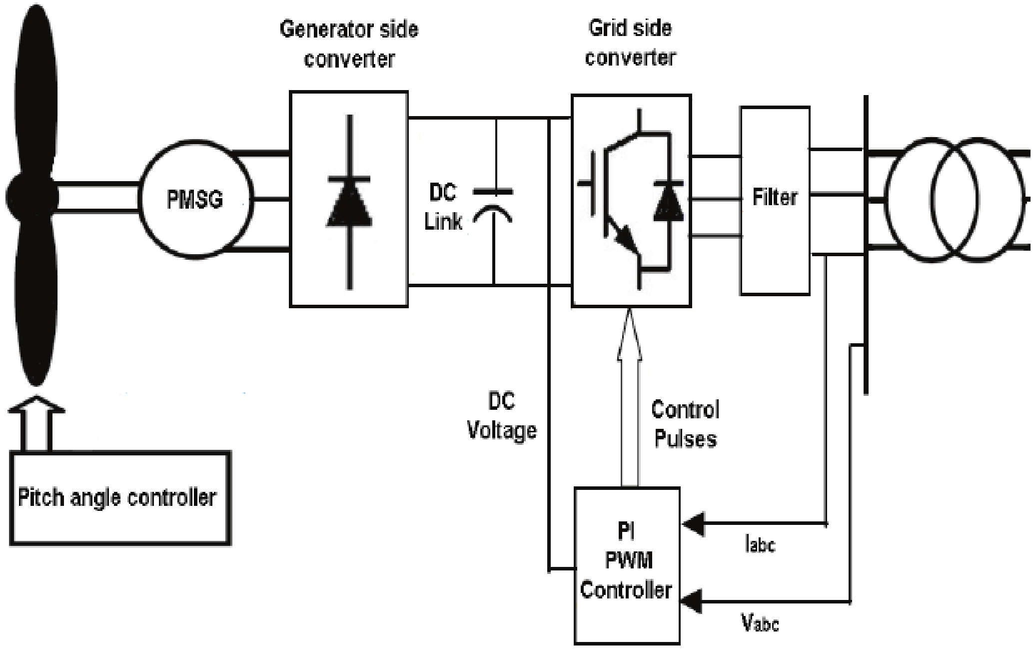
Grid Output



RESULT:

Thus the simulation and study of wind turbine characteristics were obtained by using the MatLab Simulink.

Block Diagram for Small Wind Turbine



Ex. No.6

Date:

Experiment on Performance assessment of micro–Wind Energy Generator

AIM:

To find the Performance assessment of micro–Wind Energy Generator

APPARATUS REQUIRED:

S.No.	APPARATUS	RANGE	TYPE	QUANTITY
1				
2				
3				
4				
5				
6				

PROCEDURE:

1) Make the connections as per the circuit diagram.
2) To step up the output voltage of the generator and maintain

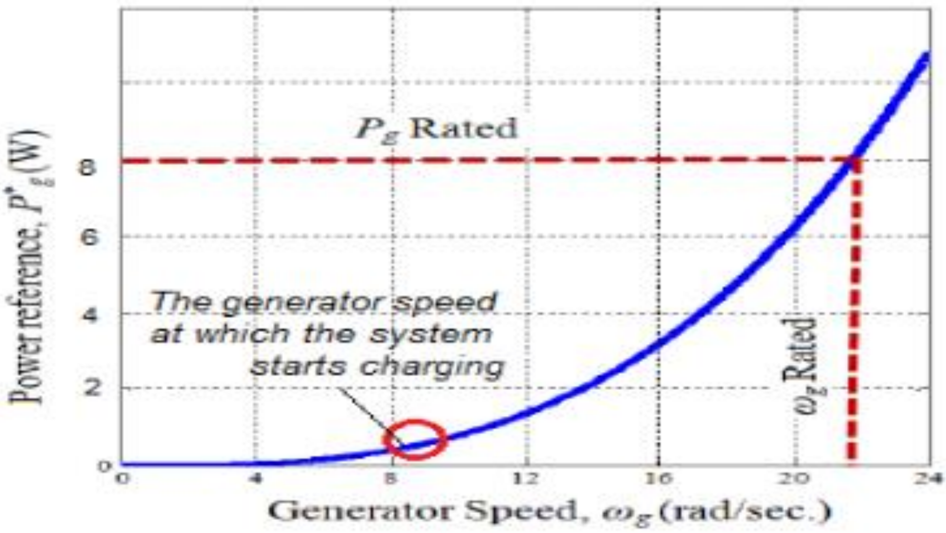
   Constant output voltage
3) DC to DC boost converter need be interfaced with the system.
4) In addition, the DC-DC converter compensates the fluctuations and maintain a smooth and a

   Continuous power flow in all operating modes.
5) The output of the DC to DC converter changed to AC output using DC/AC inverter

TABULAR COLUMN:

S.No	Wind Speed (m/s)	CP%	TSR λ	**Output Power (W)**

MODELGRAPH:



Wind Generator Vs Power

RESULT:

Thus the performance assessments of micro Wind Energy Generator were obtained.

Ex no: 7
Date:

Simulation study on Hybrid (Solar-Wind) Power System

AIM:

To study the simulation of Hybrid (Solar-Wind) Power System.

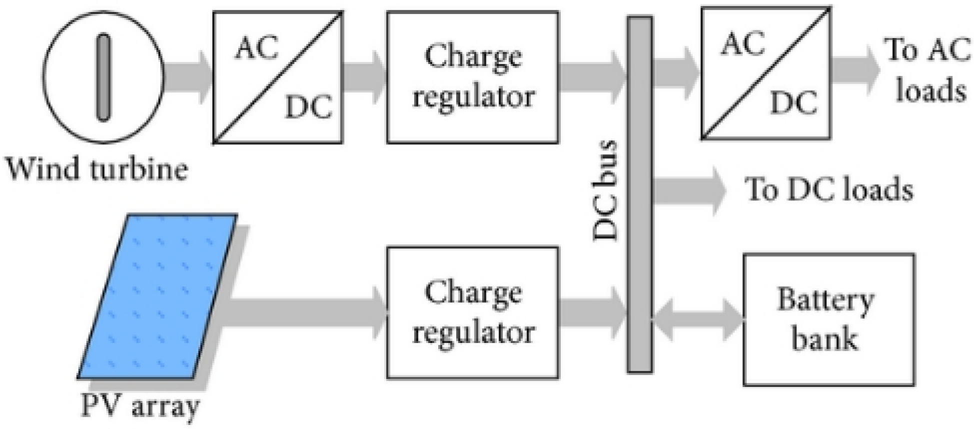
APPARATUS REQUIRED

S.No.	APPARATUS	RANGE	TYPE	QUANTITY
1	Mat lab Simulink			1
2	Solar Panel	1 KW		1
3	Inverter Circuit			1
4	Converter circuit			1
5	R-Load			1
6	Connecting wires			As required

THEORY:

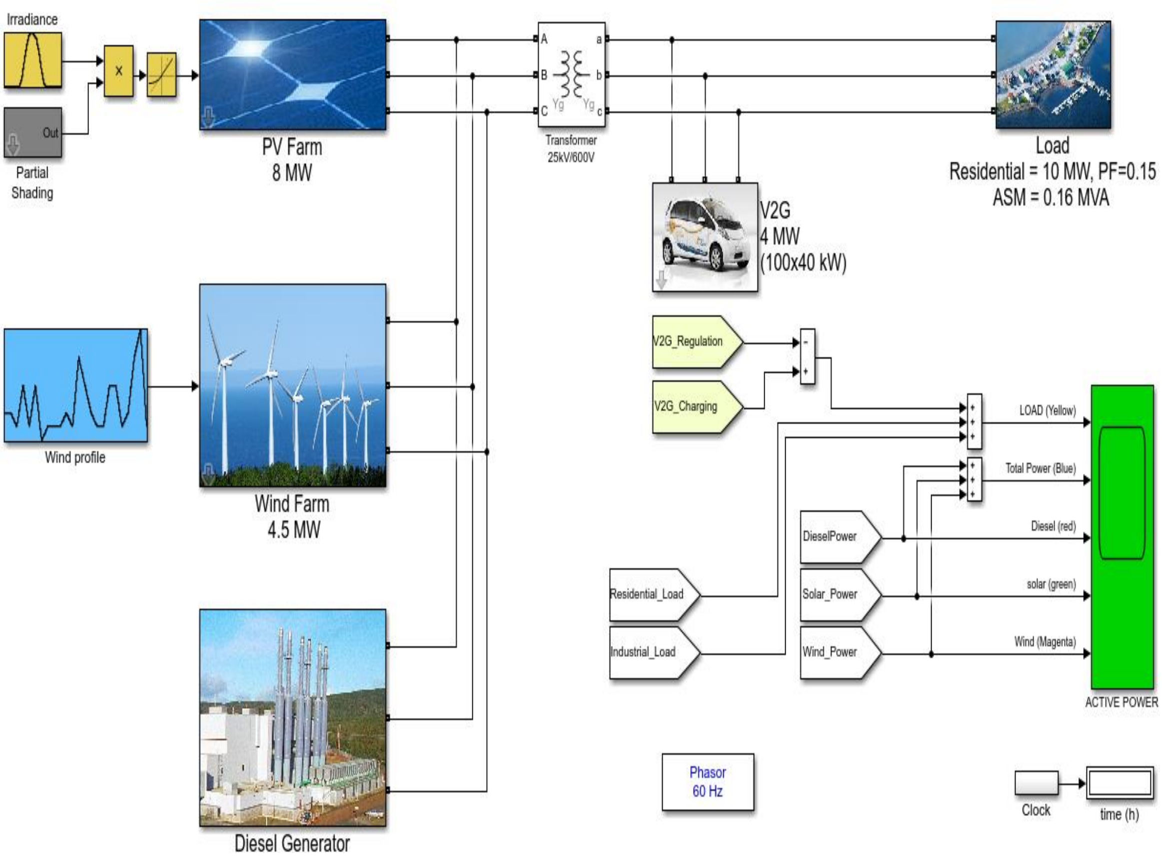
The Solar PV wind hybrid system suits to conditions where sunlight and wind has seasonal shifts. As the wind does not blow throughout the day and the sun does not shine for the entire day, using a single source will not be a suitable choice. A hybrid arrangement of combining the power harnessed from both the wind and the sun and stored in a battery can be a much more reliable and realistic power source. The load can still be powered using the stored energy in the batteries even when there is no sun or wind.

PV and wind system, both depending on weather condition, individual hybrid PV and hybrid wind system does not produce usable energy throughout the year. For better performance of the standalone individual PV combination or wind combination need battery backup unit and diesel generator set, which increase the hybrid system cost for proper operation and better reliability, and lower cost of the system, studies are reported by researchers regarding the combination of hybrid PV–wind system.



Combined solar and wind system model

Simulation diagram



PROCEDURE:

1. Matlab Simulink model file is created.
2. Simulink library used to generate required components.
3. Scope is used to view results for different conditions of shadowing.

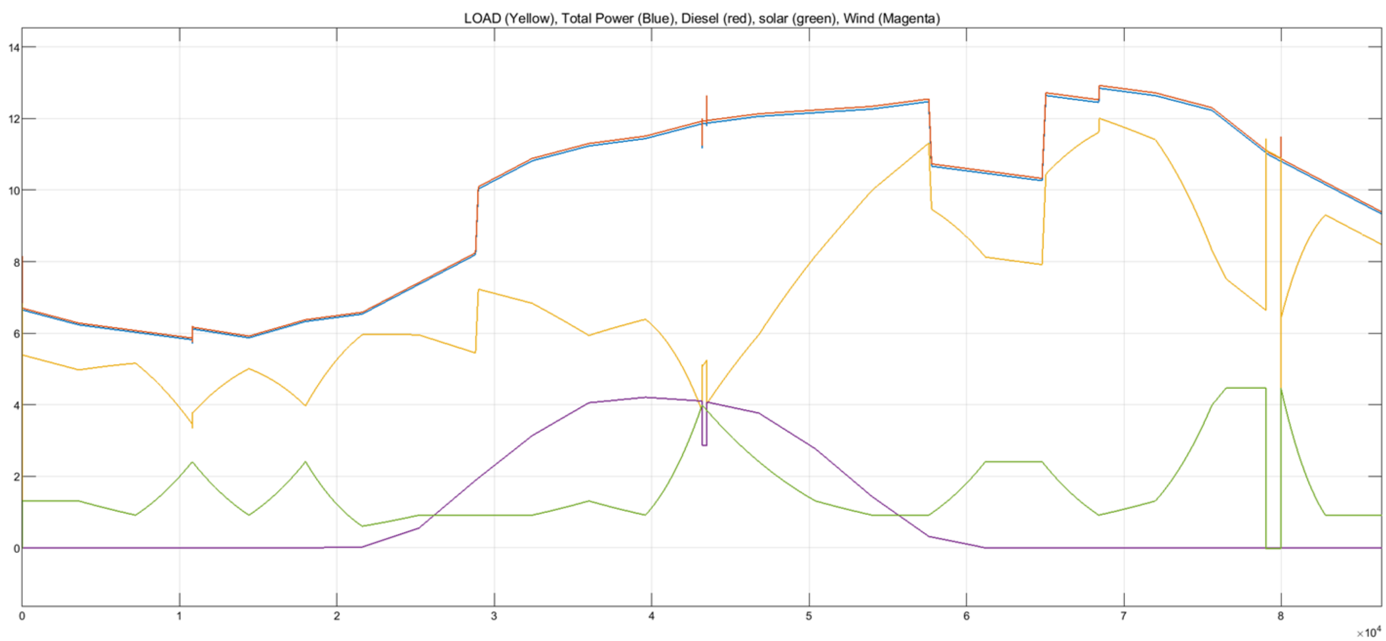
Description

The micro grid is divided into four important parts: A diesel generator, acting as the base power generator; A PV farm combined with a wind farm, to produce renewable energy; a V2G system installed next to the last part of the system which is the load of the grid. The size of the micro grid represents approximately a community of a thousand households during a low consumption day in spring or fall. There are 100 electric vehicles in the base model which means that there is a 1:10 ratio between the cars and the households. This is a possible scenario in a foreseeable future.

Load

The load is composed of residential load and an asynchronous machine that is used to represents the impact of an industrial inductive load (like a ventilation system) on the micro grid. The residential load follows a consumption profile with a given power factor. The asynchronous machine is controlled by a square relation between the rotor speed and the mechanical torque.

WIND TURBINE OUTPUT:



Result

Thus, the Hybrid (Solar-Wind) system was simulated and the outputs were verified.

Ex No:8
Date:

Experiment on Performance Assessment of Hybrid (Solar-Wind) Power System

AIM

To conduct a experiment to analyse the performance of Hybrid (Solar-Wind) Power System.

APPARATUS REQUIRED

S.No	Name of the apparatus	Range	Type	Quantity
1	PV array			
2	Wind turbine			
3	Hybrid charge collector			
4	Battery bank			
5	Inverter			
6	Load			

THEORY

PV Array Performance Model

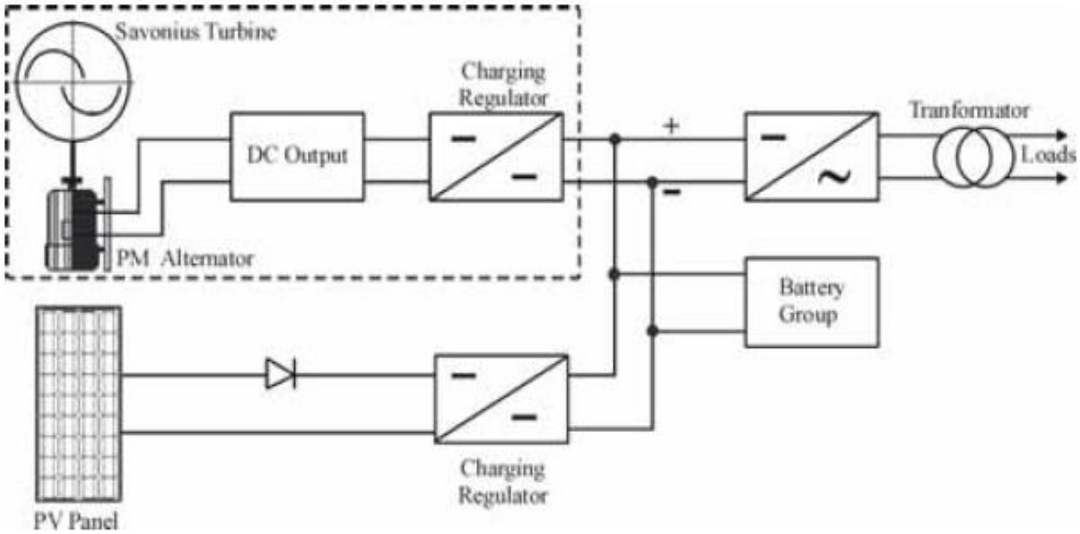
The PV module performance depends on weather conditions, especially solar radiation and PV module temperature. PV modules represent the fundamental power conversion unit of a PV system. It is mandatory to connect PV modules in series and in parallel in order to scale up the voltage and current to tailor the PV array output.

If a matrix of $N_s \times N_p$ PV modules is considered, the maximum power output of the PV system can be calculated by

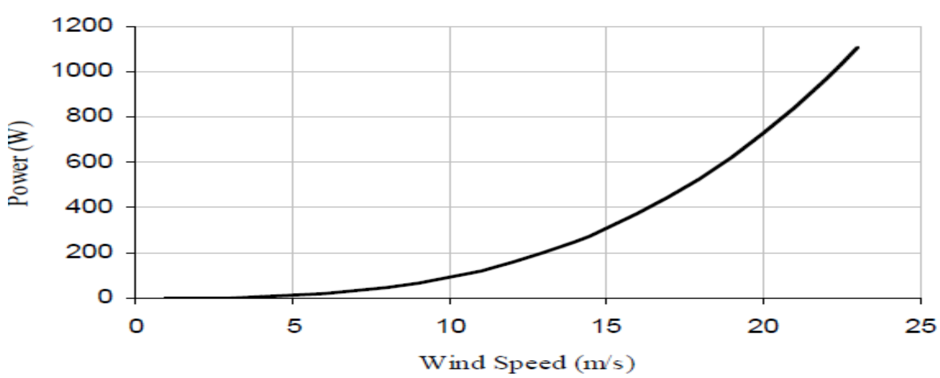
$P_{PV} = N_p . N_s . P_{module} . \eta_{MPPT} . \eta_{oth}$

η_{MPPT} is efficiency of the maximum power point tracking, (constant value of 95% is assumed)

η_{oth} is the factor representing the other losses caused by cable resistance and accumulative dust.



Combined solar and wind system model



Power curve of the savonius wind turbine

Wind Turbine Performance Model

A wind turbine turns wind energy into electricity using the aerodynamic force from the rotor blades, which work like an airplane wing or helicopter rotor blade. When wind flows across the blade, the air pressure on one side of the blade decreases. The difference in air pressure across the two sides of the blade creates both lift and drag. The force of the lift is stronger than the drag and this causes the rotor to spin. Power from Wind Turbine Generator. The wind fan may rotate in clockwise or anti clockwise direction. So the power generated from wind generator may be positive or negative, in order to get the positive power polarity corrector is connected to the wind turbine. This converts the AC power into DC power. Wind power may not be constant so a regulator circuit is connected and this regulated power is given to charge the battery

If the average wind speed reaches 10 m/s and above, SWT can produce electricity at the rated power. In the case of wind speed lower than 10m/s, electricity production is less than the rated power.

PROCEDURE:

1. Matlab Simulink model file is created.
2. Simulink library used to generate required components.
3. Scope is used to view results for different conditions of shadowing.

Result:

Thus the performance of Hybrid (Solar-Wind) Power System was observed.

Ex.No: 9
Date:

Simulation study on Hydel Power

AIM:

To study hydel power system using MATLAB Simulink software.

APPARATUS REQUIRED:

S.No	Name of the Apparatus	Range	Quantity
1.	Simulation software(MATLAB Simulink)		

THEORY:

The under damped rotor speed characteristic of hydro (synchronous) generator from the characteristics, it is observed that the transient time is 40s. After 17s its speed reaches steady state at synchronous speed. With sudden application of mechanical torque input to the shaft of alternator, the load angle settles to a steady state value after few oscillations owing to system damping following the swing equation and power angle characteristics. Moreover, the governor setting *kp*= 0.613 *ki*= 0.104 and *kd*= .0002 chosen by trial and error method helps to keep the speed near synchronous speed (1.02pu) and shows the stator current characteristics of the generator. When the load is changed, due to the presence of the transient and sub-transient reactance, envelop of three phase current shows under damped response at initial stage. After that it gains the steady state characteristics. It is observed from the plot that the transient period is 15s for three phase stators current. Active power characteristics of synchronous generator, which shows a steady state value of 0.6 pu i.e. 1800 W is nothing but the actual load connected to the plant. It is observed that the steady state is obtained around 27 sec. To reach the stable operating point on power - angle characteristics, few oscillations around this point occurs. This leads to initial overshoots and undershoots of the power characteristics.

PROCEDURE:

1. MATLAB Simulink model file is created.
2. Using Simulink library hydel power system model generated.
3. Scope is verified for different values.

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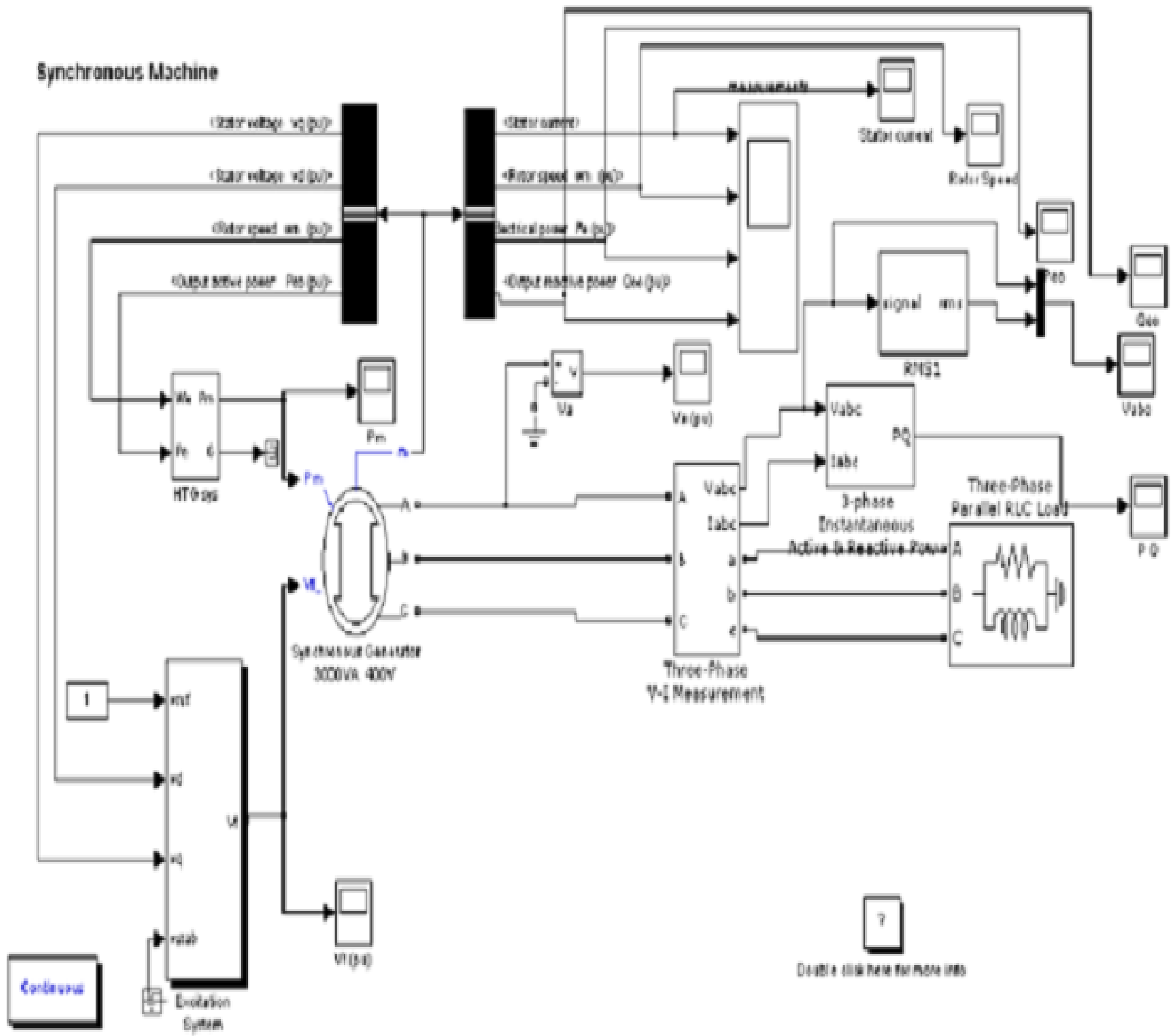
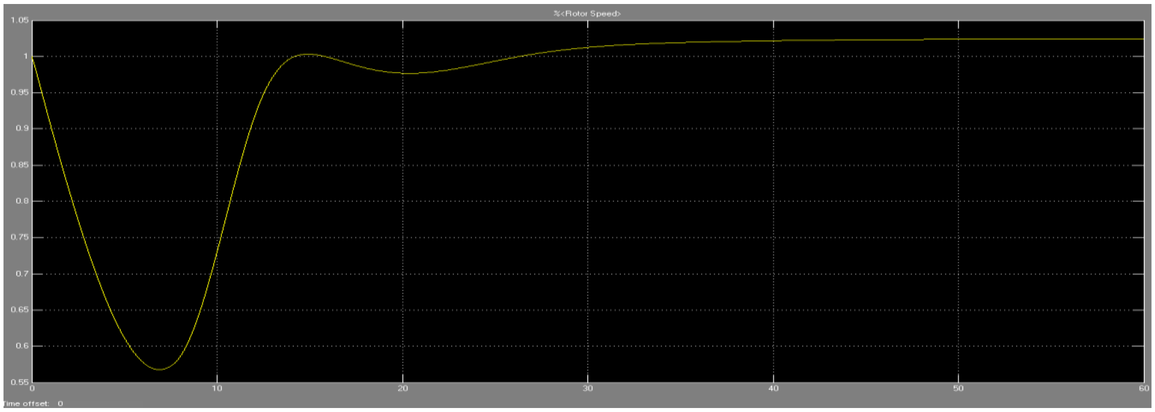
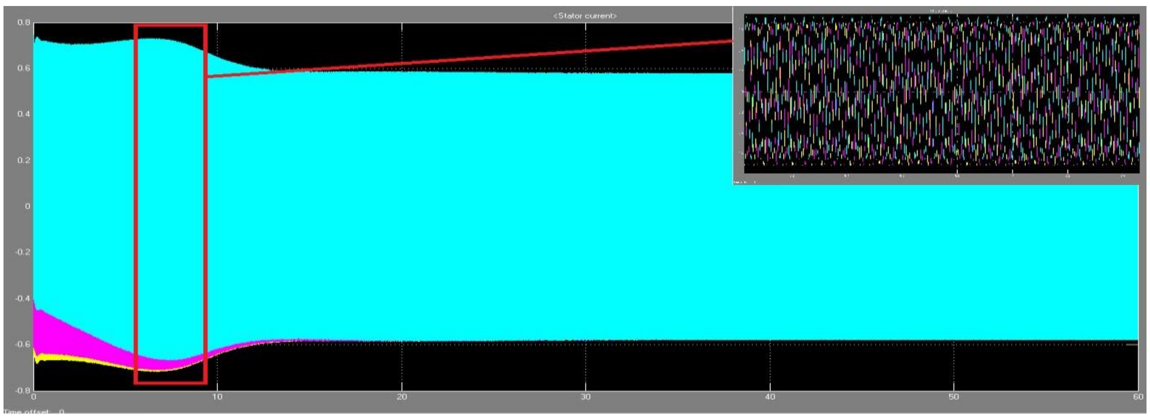


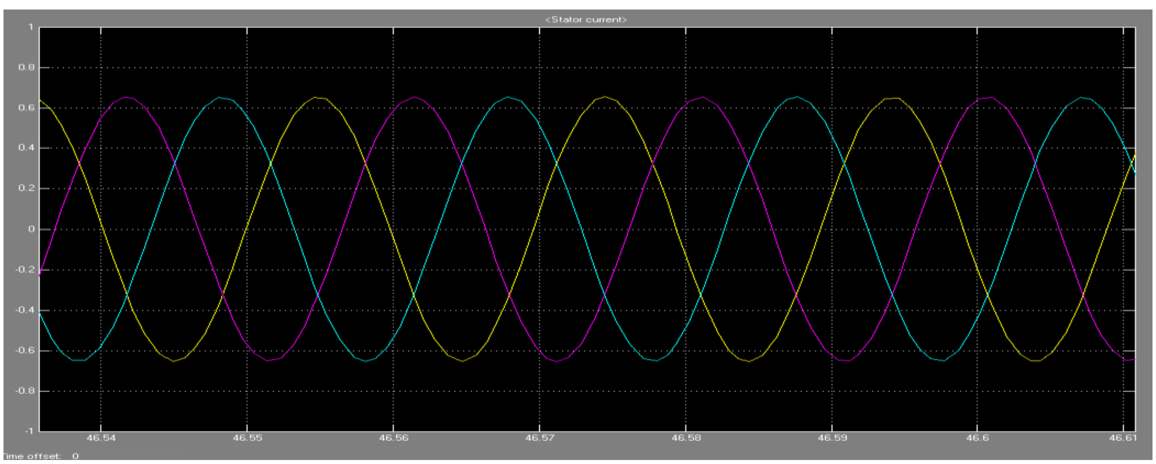
Simulink diagram



Synchronous Generator Speed Characteristics (in *y*-Axis Speed in pu and in Sec)



Stator Three Phase Current Characteristics of a Hydro Power Plant (in *y* and in *x*-Axis Time in Sec)



Stator Three Phase Current Characteristics for 0.2sec at Steady State (in *y*-Axis Current in pu and in *x*-Axis Time in Sec)

RESULT:

Thus study of simulation of hydel power systems using MATLAB Simulink model was completed.

EXP.NO:10
DATE:

Experiment on Performance Assesment of 100W Fuel Cell

AIM:

To determine the voltage-current characteristics of the 100W Fuel Cell.

APPARATUS REQUIRED:

S.No	Name of the Components / Equipment	Type/Range	Quantity required
1	Fuell cell trainer kit	FC100	
2	Connecting wires		
3	Computer with suitable software		
4	RS232 Interface		

PROCEDURE:

Set up

- Connect the AC power pack cable to the **12V**DC power input on the FC50 Fuel Cell. Connect the other end of the AC power pack to a source of AC power. On the front panel of the EL200 Electronic Load ensure the toggle switch is **OFF**. Use the AC power cord to connect the EL200 to a source of AC power; then turn on the main power switch located behind the EL200 front panel.
- Use two short test leads to connect the FC50 with the EL200, paying attention to the polarity.
- Attach the hydrogen supply quick-coupler to the FC50. Connect the 9-pin plug of the hydrogen
- supply’s solenoid valve to the **H2 SUPPLY** connector on the FC50.
- Connect the required RS-232 interface to the computer.

Start up

Starting the electrolyser

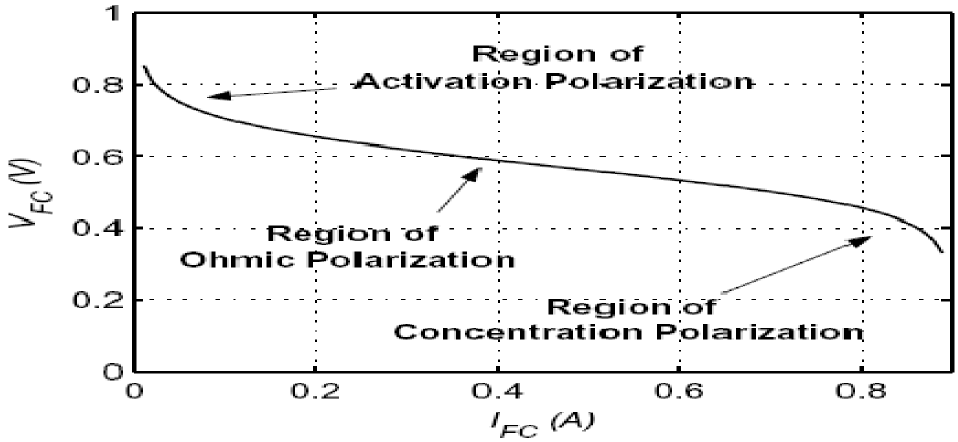
- Connect the AC power Cable to the supply and switch it ON.
- There will be a self check of 20 seconds by the electrolyser system. After that the main screen of the Graphic display will show STANDBY.
- Press the Start button and wait until the internal pressure reaches 100%. Now the display shows ready.
- Press Open**.** The external pressure will reach to the set pressure and the display will show Normal flow and Normal pressure.
- For the EL200 ensure that the 10-turn potentiometer is set to zero. Then turn ON the toggle switch on the front panel**.**
- Ensure the fan control knob is at **AUTO**. Set the main switch to **ON** and press the **START** button in the FC 50 module. After completing a system test, the green **OPERATION** light comes on and the
- FC50 is ready for use. If an error occurs, the error code will appear in the**H2 Flow** display.

Data acquisition

- For these measurements, the fuel cell should be at a temperature of 35 °C.This temperature can
- be reached by loading the fuel cell for a few minutes with a current of approximately 5 A. Using thepotentiometer of the EL200, increase the load current until the Current display on the FC50 showsapproximately 5 amperes. To further cause stack temperature to rise, turn the fan control knob on the FC50 so the Fan Power display indicates 10%.After the temperature reaches 35 °C, ensure the load potentiometer is turned back to zero and set fan control knob to AUTO.
- Using the EL200 potentiometer, set in turn each load current listed in theTable1. After waiting at
- least 15 seconds at each point, record the measured values of stack current Istack and stack voltage Vstack in the table. When measuring the first point (no-load operation) turn the toggle switch on the EL200 to OFF to ensure that there is no load on the fuel cell.

Shut down procedure

- On the EL200, turn the potentiometer to zero, set the toggle switch to **OFF,** and turnoff the
- main power switch behind the front panel.
- On the FC50, turn the fan control knob to **AUTO** and turn the main switch **OFF**.
- Shut down of the Electrolyser :
  1. Press the close button to cut the hydrogen supply. The display then shows ready mode.
  2. Now press the Stop button so that the electrolyser comes in Standby mode.
  3. Switch off the power supply.



Report Tabulation:

Nominal current (A)	**I stack(A)**	**Vstack(V)**	**Pstack(W)**	**Hydrogen Flow Rate (ml/min)**	**Temperature(°C)**

Graph

i. Draw the voltage-current characteristic *V*stack = f (Istack) of the fuel cell.
ii. Explain the resulting characteristic curve.

RESULT:

Thus voltage and current parameters for 100 fuel cell was determined and verified.

EXP.NO:11
DATE:

Simulation Study on Intelligent Controllers for Hybrid Systems

AIM:

To study the simulation of intelligent controllers for a Stand-Alone Hybrid Generation System.

THEORY:

The study aims at the modeling and power flow analysis of a stand-alone hybrid generating system (SAHGS) comprising of wind and photovoltaic systems. The wind driven self-excited induction generator (SEIG), photovoltaic array and other network components are modeled and simulated using Matlab/Simulink. The variable voltage and frequency of a generator is first rectified and controlled by a DC/DC converter before being fed to a common DC bus.

The variable output voltage of the photovoltaic module is also controlled by a DC/DC converter. The DC bus collects the total power from the wind and photovoltaic systems and uses it partly to supply the required load demand and partly to charge the battery bank. The individual systems are simulated for varying wind velocities and solar intensities respectively and the results are used to identify the operating modes. A neuro controller is designed to adjust the duty ratios of the choppers and the firing angle of the converter at which the maximum power generation occurs.

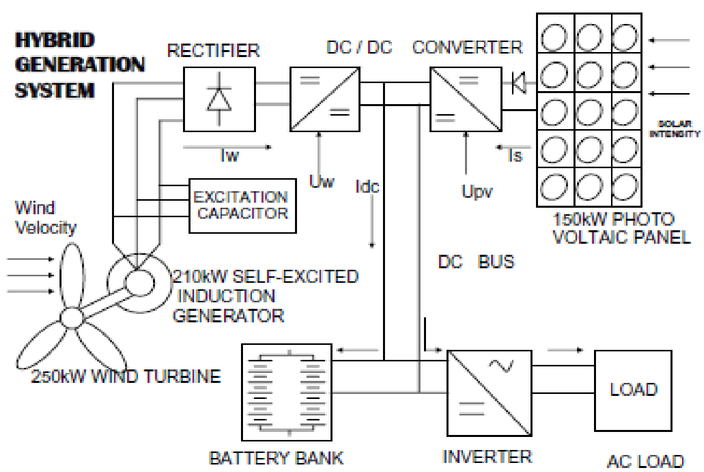


Fig. 1. Schematic Representation of a Hybrid Generation System.

The SAHGS considered for study is a combination of wind and photovoltaic systems as shown in Fig. 1. The wind system houses a 250kW wind turbine that converts the kinetic energy present in the wind into mechanical energy, which drives the 210kW self–excited induction generator through a gear box. Since the wind is an intermittent source of energy, the output voltage and frequency from the generator will vary for different wind velocities.

The variable output ac power from the generator is first converted into dc using an uncontrolled diode bridge rectifier. A buck chopper is used to match the variable DC voltage with the DC bus. The voltage across the rectifier terminal is controlled by varying the duty ratio of the DC/DC converter before it is fed to the DC bus.

The photovoltaic panel is built up of a combination of series and parallel individual photovoltaic modules. As the solar intensity varies, the DC output voltage of the panel also varies. This variable DC output voltage of the panel is controlled by another DC/DC converter before it is fed to the DC bus. The common DC bus collects the total energy from the wind and the photovoltaic systems and uses it partly to supply the required load demand and partly to charge the battery bank. Under normal operating conditions of wind velocity and solar intensity, the battery bank is an additional load to the system. It acts as an additional source to supply the demand during low wind velocities or solar intensities.

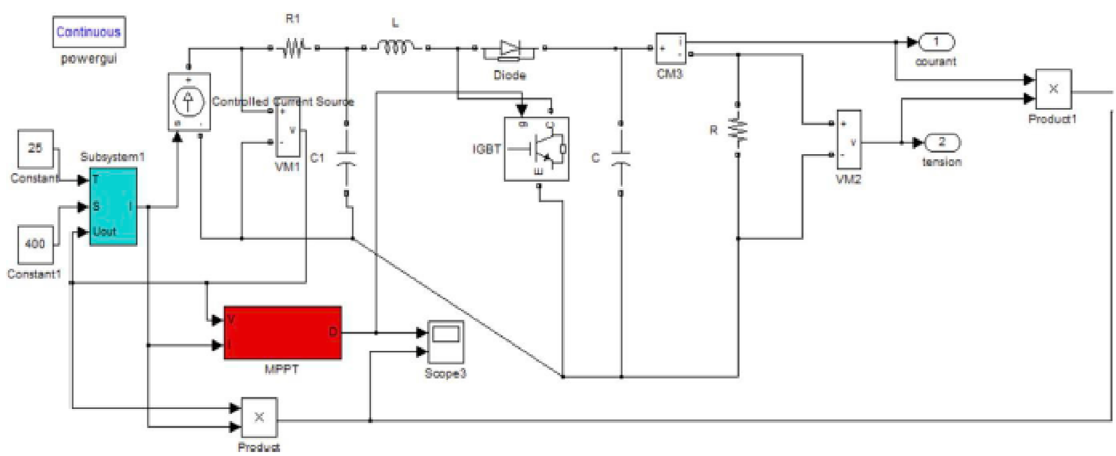


Fig.2.Model of the PV system developed under Matlab-Simulink

Response of the Neuro Controller

The neuro controller uses the wind velocity and the solar intensity as the input signals. The output of the controller is the duty ratios of the chopper and the firing angle of the controlled rectifier.Fig. 2. Simulation results of the PV system for varying cell temperatures.

The network architecture illustrated in Fig. is included in the SAHGS model for simulation. It is trained with about 150 simulation data using back propagation algorithm. The response of the controller for individual and simultaneous changes in both the wind velocity and the solar intensity are shown in Fig.2. It is observed that for every wind velocity and cell temperature,

the neuro controller automatically outputs the corresponding duty ratios of the choppers and the firing angle of the controlled rectifier respectively so as to extract maximum power and also to maintain the DC bus voltage constant.

The dynamic model of a hybrid generating system comprising a wind driven self-excited induction generator, photovoltaic system and the power conditioning circuit (uncontrolled rectifier –buck chopper) is developed. The individual system performance of the wind and PV systems are studied through simulation for varying wind velocities and solar intensities respectively. From the simulation results, the optimum value of excitation, capacitance and number of batteries are identified. It is found that the power generation increases with decreasing duty ratio (in turn the input voltage to the chopper) and the maximum generations found to be 92 kW at dw =0.1 and 150kW at dPV =0.13 respectively. A further reduction in dc voltage is obtained by using a controlled rectifier and improvement in power generation is found to be about 17 percent of rated value. The simulation is repeated for varying wind velocities and the optimum value of alpha and duty ratio are found. Similar analysis is carried out for the solar system also and the optimum duty ratio is found for different cell temperatures. The neuro controller designed for the automatic variation of dw, dPV and alpha exhibits an excellent dynamic response.

RESULT:

Thus, the study of simulation of intelligent controllers for a Stand-Alone Hybrid Generation System has been done.