ST.ANNE'S

COLLEGE OF ENGINEERING AND TECHNOLOGY

ANGUCHETTYPALAYAM, PANRUTI-607 106.

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

EE8712
RENEWABLE ENERGY SYSTEMS LABORATORY

OBSERVATION

For

IV YEAR / VII SEMESTER

B.E. ELECTRICAL AND ELECTRONICS ENGINEERING

NAME : ……………………………………………….………………...

REGISTER No. : ……………………………………………….………………...

DOs and DON'T DOs in Laboratory

1. Understand the equipment to be tested and apparatus to be used.
2. Always start the experiment with PV module cleaning.
3. Conduct one set of each experiment within 2-3 minutes.
4. Don't short the battery terminals or any other source terminals.
5. Don't move the halogen or PV module while the experiment is going on.
6. Don't connect the module o/p to the charge controller before connecting the battery with charge controller.
7. Don't allow the module temperature above 700C.
8. Select proper type (AC or DC) and range of meters, Use suitable wires (type and size).
9. Never exceed the permissible values of current, voltage, and / or speed of any machine.
10. Strictly observe the instructions given by the Staff / Lab Instructor

LIST OF EXPERIMENTS

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 in 1kWp Solar PV System".
4. Experiment on Performance assessment of Grid connected and Standalone 1kWp Solar Power System.
5. Simulation study on Wind Energy Generator.
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

INDEX

Ex. No.	DATE	EXPERIMENT	REMARKS	SIGNATURE
1 a		Experiment on “VI-Characteristics of Solar PV System”.		
1 b		Experiment on “Efficiency of Solar PV System”.		
2 a		Experiment on “Shadowing effect in Solar PV System”.		
2 b		Experiment on “diode based solution in Solar PV System”.		
3 a		Experiment on Performance assessment of Grid connected Solar Power System.		
3 b		Experiment on Performance assessment of Standalone Solar Power System.		
4		Experiment on Performance assessment of micro Wind Energy Generator.		
5		Experiment on Performance Assessment of Hybrid (Solar-Wind) Power System.		
6		Simulation study on Solar PV Energy System.		
7		Simulation study on Wind Energy Generator.		
8		Simulation study on Hybrid (Solar-Wind) Power System.		
9		Simulation study on Hydel Power.		
10		Simulation study on Performance Assessment of 100W Fuel Cell.		
11		Simulation study on Intelligent Controllers for Hybrid Systems		

Ex. No.: 1 a
Date :

EXPERIMENT ON VI CHARACTERISTICS OF SOLAR PV SYSTEM

AIM:

To draw the I-V and P-V characteristics of PV module with varying radiation and Calculate the fill factor for the given module.

APPARATUS REQUIRED:

Sl. No.	Apparatus Name	Range	Quantity
1	PV module	12 V, 165 W 5A	1
2	Solar PV trainer kit	-	1
3	Inverter module	600VA (10-15)V	1
4	Battery	12V, 40AH	1
5	LUX Meter	-	1
6	Thermocouple	-	1
7	DC Lamp (Load)	9W	5
8	Connecting wires	-	As required

FORMULA USED:

Fill Factor (FF) = $\frac{P_{Max}}{P_T} = \frac{I_{MP} \, X \, V_{MP}}{I_{SC} \, X \, V_{OC}}$

Power P = V X I

Where P_{Max} = Achievable maximum power in W

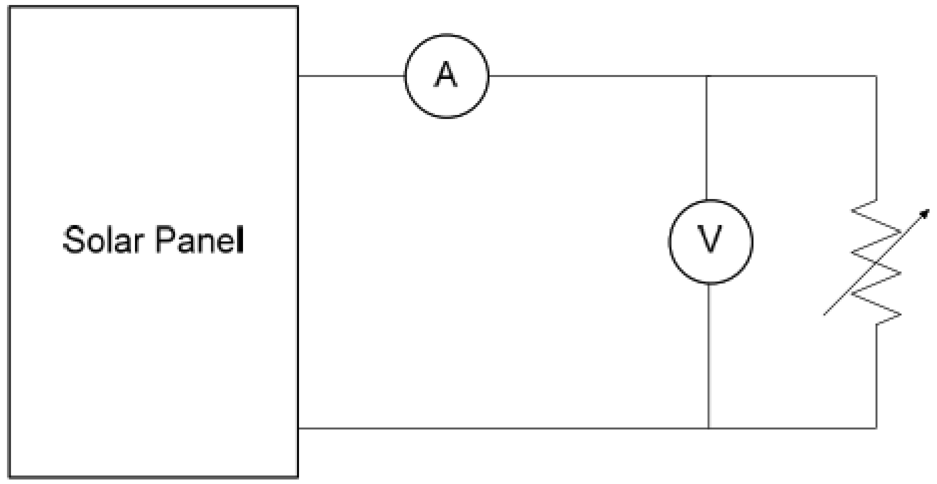
P_T = Theoretical maximum power in W

THEORY:

PV module is characterized by its I-V and P-V characteristics. In I-V characteristic maximum current at zero voltage is the short circuit current (Isc) which can be measured by shorting the PV module and maximum voltage at zero current is the open circuit voltage (Voc). In P-V curve the maximum power is achieved only at a single point which is called MPP (maximum power point) and the voltage and current corresponding to this point are referred as Vmp and Imp. On increasing the temperature, Voc of module decreases as shown in Fig. 1.2, while Isc remains the same which in turn reduces the power. For most crystalline silicon solar cells modules the reduction is about 0.50%/°C. On changing the solar insolation Isc of the module increases while the Voc increases very slightly

Fill factor: The Fill Factor (FF) is essentially a measure of quality of the solar cell. It is the ratio of the actual achievable maximum power to the theoretical maximum power (PT) that would be achieved with open circuit voltage and short circuit current together. FF can also be interpreted graphically as the ratio of the rectangular areas depicted. A larger fill factor is desirable, and corresponds to an I-V sweep that is more square-like. Typical fill factors range from 0.5 to 0.82. Fill factor is also often represented as a percentage

CIRCUIT DIAGRAM



TABULATION:

Set: 1

S.No	Radiation (Lux)	Temperature (C)	Voltage (V)	Current (A)	Power (W)
1			(Voc)	0	
2					
3					
4					
5					
6					
7			0	(I_{SC})	

Set: 2

S.No	Radiation (Lux)	Temperature (C)	Voltage (V)	Current (A)	Power (W)
1			(Voc)	0	
2					
3					
4					
5					
6					
7			0	(I_{SC})	

Set: 3

S.No	Radiation (Lux)	Temperature (C)	Voltage (V)	Current (A)	Power (W)
1			(Voc)	0	
2					
3					
4					
5					
6					
7			0	(I_{SC})	

Set: 4

S.No	Radiation (Lux)	Temperature (C)	Voltage (V)	Current (A)	Power (W)
1			(Voc)	0	
2					
3					
4					
5					
6					
7			0	(I_{SC})	

PRECAUTIONS:

1. Readings for one set should be taken within 1-2 minutes (for indoor exp.) otherwise temperature of the module may vary as radiation source used is halogen lamp.
2. Always take radiation reading after module current and voltage readings.

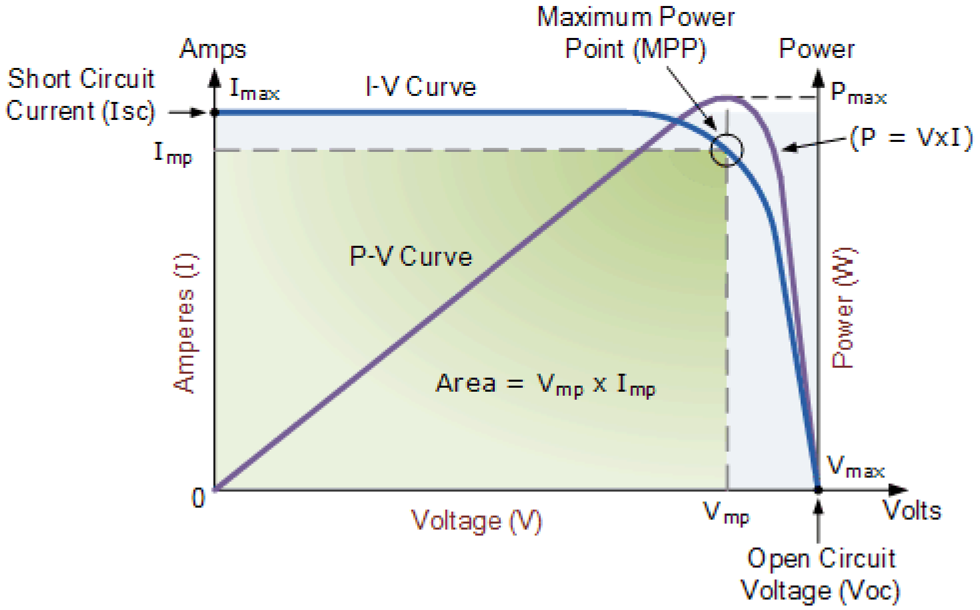
PROCEDURE:

1. Connections are made in Control board.
2. Set radiation level
3. Note temperature level
4. Switch Battery – OFF, Mains – OFF, Inverter - OFF
5. At no load condition, note the voltage (Voc).
6. Switch on the load and note down the Voltage and current
7. Short circuit the module and note down the current (Isc)
8. Draw the graph.

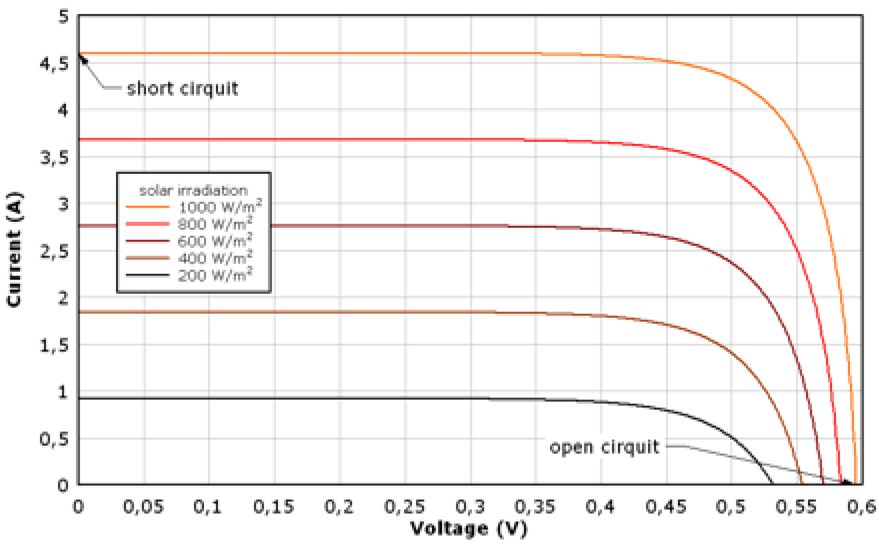
CALCULATION:

MODEL GRAPH:

I-V characteristic and P-V Characteristic of PV module



Variation in I-V characteristic with insolation



RESULT:

1. Draw the I-V curves of all the sets on a single graph and show the characteristics at different radiation and temperatures levels
2. Draw the P-V curves of all sets on a single graph and show the characteristics at different radiation and temperatures levels.
3. Calculate the fill factor for the given module

Ex. No.: 1 b
Date :

EXPERIMENT ON EFFICIENCY OF SOLAR PV SYSTEM

AIM:

To calculate the efficiency of a solar PV system for the given module.

APPARATUS REQUIRED:

Sl. No.	Apparatus Name	Range	Quantity
1	PV module	12 V, 165 W 5A	1
2	Solar PV trainer kit	-	1
3	Inverter module	600VA (10-15)V	1
4	Battery	12V, 40AH	1
5	LUX Meter	-	1
6	Thermocouple	-	1
7	DC Lamp (Load)	9W	5
8	Connecting wires	-	As required

FORMULA USED:

Solar cell Efficiency (Maximum):-

$$\eta_{max} = \frac{P_{max}}{E * A_c} \text{ X } 100 \%$$

P_{max} = Maximum Power Output (in W)
E = incident radiation flux (in W/m^2)
A_c = Area of Collector (in m^2)

$$\eta = \frac{P_{max}}{P_{in}} = \frac{I_m V_m}{P_{in}} = \frac{I_{sc} V_{oc}}{P_{in}} \times FF$$

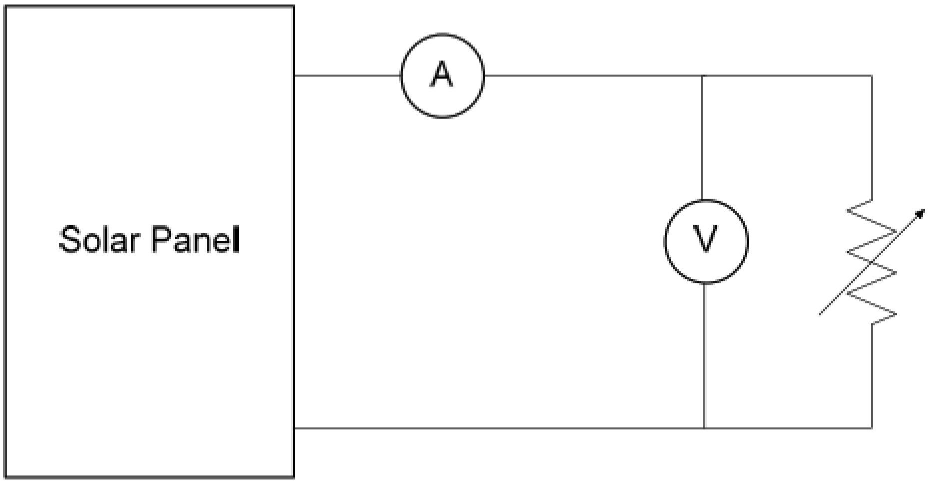
P_{in} is the input power (solar radiation)

THEORY:

PV module is characterized by its I-V and P-V characteristics. In I-V characteristic maximum current at zero voltage is the short circuit current (Isc) which can be measured by shorting the PV module and maximum voltage at zero current is the open circuit voltage (Voc). In P-V curve the maximum power is achieved only at a single point which is called MPP (maximum power point) and the voltage and current corresponding to this point are referred as Vmp and Imp. On increasing the temperature, Voc of module decreases as shown in Fig. 1.2, while Isc remains the same which in turn reduces the power. For most crystalline silicon solar cells modules the reduction is about 0.50%/°C. On changing the solar insolation Isc of the module increases while the Voc increases very slightly

Fill factor: The Fill Factor (FF) is essentially a measure of quality of the solar cell. It is the ratio of the actual achievable maximum power to the theoretical maximum power (PT) that would be achieved with open circuit voltage and short circuit current together. FF can also be interpreted graphically as the ratio of the rectangular areas depicted. A larger fill factor is desirable, and corresponds to an I-V sweep that is more square-like. Typical fill factors range from 0.5 to 0.82. Fill factor is also often represented as a percentage

CIRCUIT DIAGRAM



TABULATION:

Set: 1

S.No	Radiation (Lux)	Temperature (C)	Voltage (V)	Current (A)	Power (W)
1			(Voc)	0	
2					
3					
4					
5					
6					
7			0	(I_{SC})	

Set: 2

S.No	Radiation (Lux)	Temperature (C)	Voltage (V)	Current (A)	Power (W)
1			(Voc)	0	
2					
3					
4					
5					
6					
7			0	(I_{SC})	

Set: 3

S.No	Radiation (Lux)	Temperature (C)	Voltage (V)	Current (A)	Power (W)
1			(Voc)	0	
2					
3					
4					
5					
6					
7			0	(I_{SC})	

Set: 4

S.No	Radiation (Lux)	Temperature (C)	Voltage (V)	Current (A)	Power (W)
1			(Voc)	0	
2					
3					
4					
5					
6					
7			0	(I_{SC})	

PRECAUTIONS:

1. Readings for one set should be taken within 1-2 minutes (for indoor exp.) otherwise temperature of the module may vary as radiation source used is halogen lamp.
2. Always take radiation reading after module current and voltage readings.

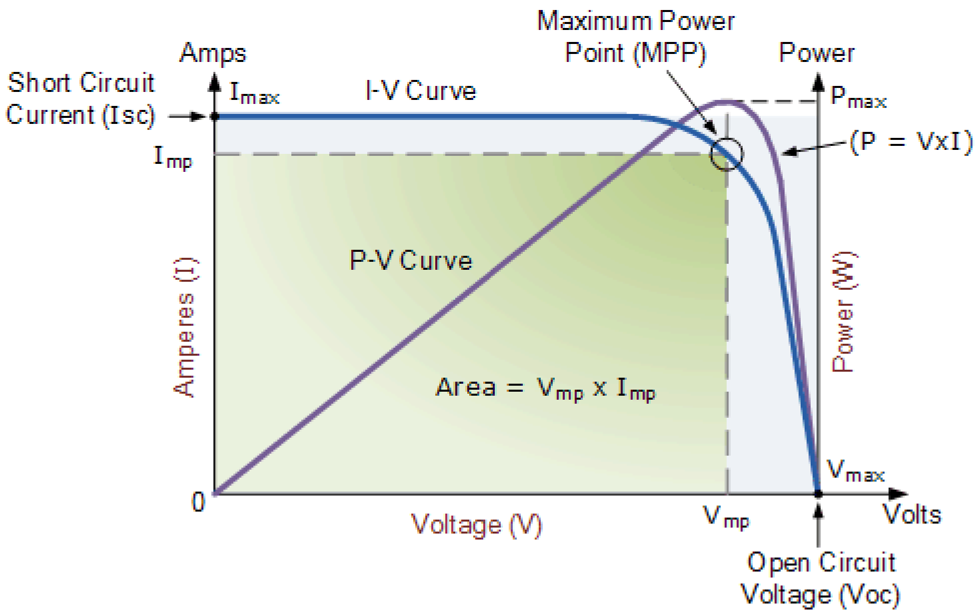
PROCEDURE:

1. Connections are made in Control board.
2. Set radiation level
3. Note temperature level
4. Switch Battery – OFF, Mains – OFF, Inverter - OFF
5. At no load condition, note the voltage (Voc).
6. Switch on the load and note down the Voltage and current
7. Short circuit the module and note down the current (Isc)
8. Draw the graph.
9. Find the Pmax

CALCULATION:

MODEL GRAPH:

I-V characteristic and P-V Characteristic of PV module



RESULT:

1. Draw the I-V curves of all the sets on a single graph and show the characteristics at different radiation and temperatures levels
2. Draw the P-V curves of all sets on a single graph and show the characteristics at different radiation and temperatures levels.
3. Calculate the efficiency for the given module

Ex. No.: 2 a
Date :

EXPERIMENT ON SHADOWING EFFECT IN SOLAR PV SYSTEM

AIM:

To measure the effect of shading on PV module output power for the given module.

APPARATUS REQUIRED:

Sl. No.	Apparatus Name	Range	Quantity
1	PV module	12 V, 165 W 5A	1
2	Solar PV trainer kit	-	1
3	Inverter module	600VA (10-15)V	1
4	Battery	12V, 40AH	1
5	LUX Meter	-	1
6	Thermocouple	-	1
7	DC Lamp (Load)	9W	5
8	Connecting wires	-	As required

FORMULA USED:

Power P = V X I

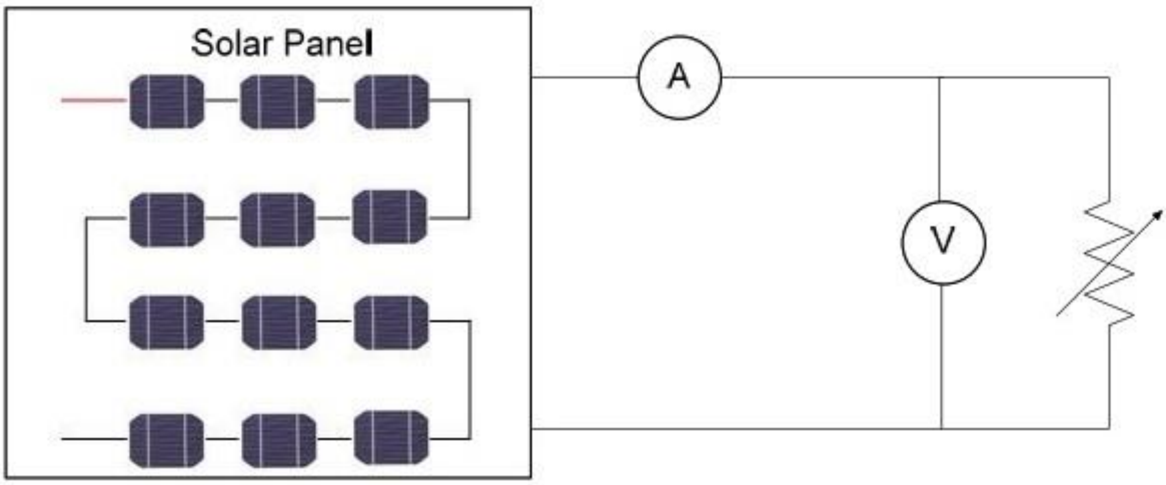
Where V = Voltage in V (V)

I = Current in I (A)

THEORY:

PV cells are in series without bypass diode so shading of one cell will be sufficient to reduce the power to zero. This arrangement gives zero power if the entire row of cells gets shaded.

CIRCUIT DIAGRAM



TABULATION:

S.No	Type of shading element	Voltage (V)	Current (A)	Power (W)
1	**No cell is shaded**			
2	**25% cell is shaded**			
3	**50% cell is shaded**			
4	**75% cell is shaded**			
5	**100% cell is shaded**			

PRECAUTIONS:

1. Readings for one set should be taken within 1-2 minutes (for indoor exp.) otherwise temperature of the module may vary as radiation source used is halogen lamp.
2. Shading of string should be exactly on that string only
3. Always take radiation reading after module current and voltage readings.

PROCEDURE:

1. Connections are made in Control board.
2. Set radiation level
3. Note temperature level
4. Switch Battery – OFF, Mains – OFF, Inverter - OFF
5. Switch on load (Full Load)
6. Switch on the load and note down the Voltage and current
7. Shade the cells and note down the Voltage and current

CALCULATION:

RESULT:

The effect of shading on PV module output power for the given module is determined.

Ex. No.: 2 b
Date :

EXPERIMENT ON DIODE BASED SOLUTION IN SOLAR PV SYSTEM

AIM:

To demonstrate the working of diode as Bypass diode and blocking diode.

APPARATUS REQUIRED:

Sl. No.	Apparatus Name	Range	Quantity
1	PV module	12 V, 165 W 5A	1
2	Solar PV trainer kit	-	1
3	Inverter module	600VA (10-15)V	1
4	Battery	12V, 40AH	1
5	LUX Meter	-	1
6	Thermocouple	-	1
7	DC Lamp (Load)	9W	5
8	Connecting wires	-	As required

FORMULA USED:

Power P = V X I

Where V = Voltage in V (V)

I = Current in I (A)

THEORY:

Diode is very important element in the PV system. This element can work as a blocking diode or as a bypass diode. Diodes connected in series with cells or modules are called blocking diodes and diodes connected across cells or modules are called bypass diodes. There are two situations where these diodes can help.

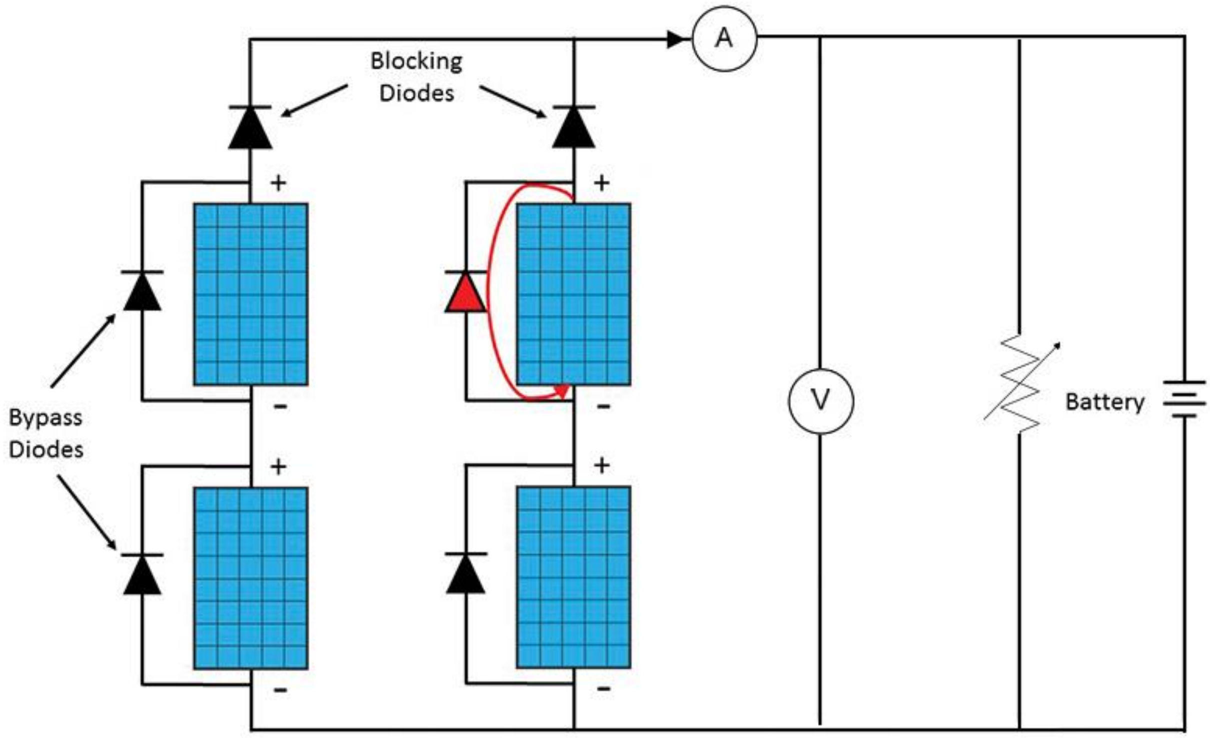
Bypass action of diode

If two modules are in series then the current in circuit will be decided by the module which is generating less current. Hence if one module is completely shaded then the current in the circuit will be zero. If there is a diode in parallel with the shaded module then power output of non-shaded module gets bypassed by diode and will be available at load terminals.

Blocking reverse flow of current from the battery through the module at night.

In battery charging systems, the module potential drops to zero at night when sunlight is not available. The battery could discharge at night time by flowing current backwards through the module. This would not be harmful to the module, but would result in loss of precious energy from the battery bank. To prevent the current flow from the battery to the module at night time blocking diode is placed in the circuit between the module and the battery.

CIRCUIT DIAGRAM



TABULATION:

S.No.	Module Configuration	Array Voltage (V)	Array Current (A)	Array Power (W)	Load Voltage (V)	Load Current (A)	Load Power (W)	Battery Voltage (V)	Battery Current (A)	Battery Power (W)
1	Single module									
2	Parallel connected modules									

PRECAUTIONS:

1. Readings for one set should be taken within 1-2 minutes (for indoor exp.) otherwise temperature of the module may vary as radiation source used is halogen lamp.
2. Shading of string should be exactly on that string only
3. Always take radiation reading after module current and voltage readings.

PROCEDURE:

1. Connections are made in Control board.
2. Set radiation level
3. Note temperature level
4. Switch Battery – ON, Mains – ON, Inverter - OFF
5. Switch on load (Full Load)
6. Switch on the load and note down the Voltage and current
7. Connect two module in parallel with diode in series and repeat the experiment.

CALCULATION:

RESULT:

Thus the working of diode as Bypass diode and blocking diode was tested.

Ex. No.: 3 a
Date :

EXPERIMENT ON PERFORMANCE ASSESSMENT OF GRID CONNECTED SOLAR POWER SYSTEM

AIM:

To calculate the power flow of Grid connected PV system of DC and AC load with battery for the given module.

APPARATUS REQUIRED:

Sl. No.	Apparatus Name	Range	Quantity
1	PV module	12 V, 165 W 5A	1
2	Solar PV trainer kit	-	1
3	Inverter module	600VA (10-15)V	1
4	Battery	12V, 40AH	1
5	LUX Meter	-	1
6	Thermocouple	-	1
7	DC Lamp (Load)	9W	5
8	AC Lamp (Load)	40W	5
9	Connecting wires	-	As required

FORMULA USED:

1. Array power = DC load power +AC load power + battery power+ loss due to charge controller.

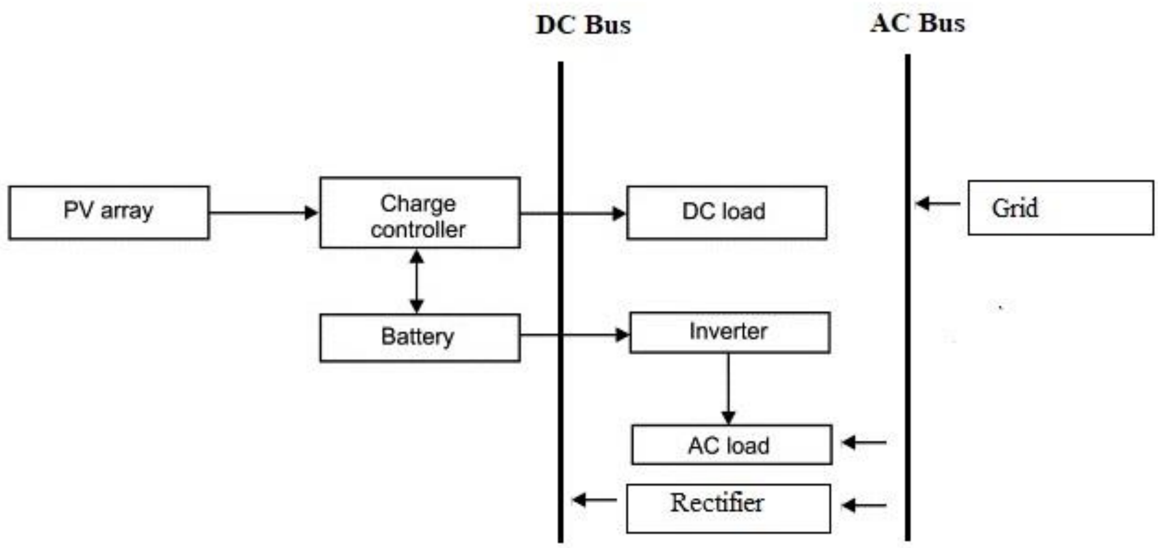
2. Inverter efficiency = AC load power*100/Inverter input power

THEORY:

Grid connected system is the one which can be used for both AC and DC loads and installed near the location of load. These systems are easy to install and understand. These systems can be used without batteries also but these systems perform best with battery bank. These systems are best suited for the locations where grid connectivity is present and these systems fulfill the requirements of these locations.

This system use DC power to charge the battery and run the DC load but, use AC power to run the AC load. There are modules, charge controller, batteries, DC load, inverter and AC load in this system. This system runs the AC and DC load simultaneously and can fulfill the demand of the both types of loads.

BLOCK DIAGRAM



TABULATION:

Tables for grid connected PV system calculation:

S.No.	Module Configuration	Array Current	Array Voltage	Array Power	DC Load Current	DC Load Voltage	DC Load Power	Inverter I/P Current	Inverter I/P	Inverter I/P Power	Battery Current	Battery Voltage	Battery Power
		(A)	(V)	(W)	(A)	(V)	(W)	(A)	(V)	(W)	(A)	(V)	(W)
1	Single module												
2	Parallel connected modules												

Table for inverter efficiency:

S.No.	Module Configuration	Inverter I/P Current	Inverter I/P Voltage	Inverter I/P Power	AC Load Current	AC Load Voltage	AC Load Power
		(A)	(V)	(W)	(A)	(V)	(W)
1	Single module						
2	Parallel connected modules						

PRECAUTIONS:

1. Readings for one set should be taken within 1-2 minutes (for indoor exp.) otherwise temperature of the module may vary as radiation source used is halogen lamp.
2. Always take radiation reading after module current and voltage readings.

PROCEDURE:

1. Connections are made in Control board.
2. Set radiation level
3. Note temperature level
4. Switch Battery – ON, Mains – ON, Inverter - ON
5. Switch on load (Full Load)
6. Switch on the load and note down the Voltage and current
7. Connect two module in parallel with diode in series and repeat the experiment.

CALCULATION:

RESULT:

Thus the power flow of Grid connected PV system of DC and AC load with battery for the given module is calculated.

Ex. No.: 3 b
Date :

EXPERIMENT ON PERFORMANCE ASSESSMENT OF STANDALONE SOLAR POWER SYSTEM

AIM:

To calculate the power flow of stand- alone PV system of DC and AC load with battery for the given module.

APPARATUS REQUIRED:

Sl. No.	Apparatus Name	Range	Quantity
1	PV module	12 V, 165 W 5A	1
2	Solar PV trainer kit	-	1
3	Inverter module	600VA (10-15)V	1
4	Battery	12V, 40AH	1
5	LUX Meter	-	1
6	Thermocouple	-	1
7	DC Lamp (Load)	9W	5
8	AC Lamp (Load)	40W	5
9	Connecting wires	-	As required

FORMULA USED:

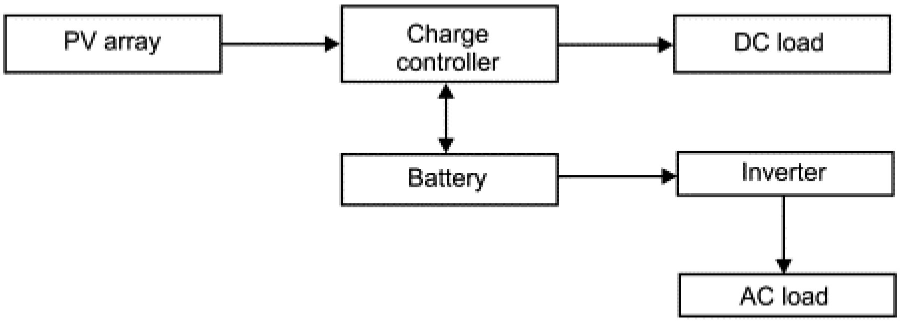
1. Array power = DC load power +AC load power + battery power+ loss due to charge controller.
2. Inverter efficiency = AC load power*100/Inverter input power

THEORY:

Stand-alone system) is the one which can be used for both AC and DC loads and installed near the location of load. These systems are easy to install and understand. These systems can be used without batteries also but these systems perform best with battery bank. These systems are best suited for the locations where grid connectivity is not present and these systems fulfill the requirements of these locations.

This system use DC power to charge the battery and run the DC load but, use AC power to run the AC load. There are modules, charge controller, batteries, DC load, inverter and AC load in this system. This system runs the AC and DC load simultaneously and can fulfill the demand of the both types of loads.

BLOCK DIAGRAM



TABULATION:

Tables for Stand-alone PV system calculation:

S.No.	Module Configuration	Array Current	Array Voltage	Array Power	DC Load Current	DC Load Voltage	DC Load Power	Inverter I/P Current	Inverter I/P	Inverter I/P Power	Battery Current	Battery Voltage	Battery Power
		(A)	(V)	(W)	(A)	(V)	(W)	(A)	(V)	(W)	(A)	(V)	(W)
1	Single module												
2	Parallel connected modules												

Table for inverter efficiency:

S.No.	Module Configuration	Inverter I/P Current	Inverter I/P Voltage	Inverter I/P Power	AC Load Current	AC Load Voltage	AC Load Power
		(A)	(V)	(W)	(A)	(V)	(W)
1	Single module						
2	Parallel connected modules						

PRECAUTIONS:

1. Readings for one set should be taken within 1-2 minutes (for indoor exp.) otherwise temperature of the module may vary as radiation source used is halogen lamp.
2. Always take radiation reading after module current and voltage readings.

PROCEDURE:

1. Connections are made in Control board.
2. Set radiation level
3. Note temperature level
4. Switch Battery – ON, Mains – OFF, Inverter - ON
5. Switch on load (Full Load)
6. Switch on the load and note down the Voltage and current
7. Connect two module in parallel with diode in series and repeat the experiment.

CALCULATION:

RESULT:

Thus the power flow of stand- alone PV system of DC and AC load with battery for the given module is calculated.

Ex. No.: 4
Date :

EXPERIMENT ON PERFORMANCE ASSESSMENT OF MICRO WIND ENERGY GENERATOR

AIM:

To Evaluate the coefficient of performance of wind turbine.

APPARATUS REQUIRED:

Sl. No.	Apparatus Name	Range	Quantity
1	Wind Generator PMSG (3 phase)	100W	1
2	Wind trainer kit	-	1
3	Inverter module	600VA (10-15)V	1
4	Battery	12V, 40AH	1
5	Anemometer	-	1
6	DC Lamp (Load)	9W	5
7	AC Lamp (Load)	40W	5
8	Connecting wires	-	As required

FORMULA USED:

power can be calculated by

P (electrical) = [(DC load voltage*DC load current) + (battery voltage*battery current)]*charge controller efficiency
OR
P (electrical) = [(inverter i/p voltage*inverter i/p current) + (battery voltage*battery current)]*charge controller efficiency

Wind speed will be measured with the help of anemometer which is placed just behind the turbine. Power in wind flow can be measured by following formula

P (wind) = ρ*A*V3/2

Power will be calculated at different wind speed and then coefficient of performance will be evaluated at different wind speed.

DC power at output of charge controller (DC power) = (DC load voltage*DC load current) + (battery voltage*battery current)
OR
DC power at output of charge controller (DC power) = (inverter i/p current*inverter i/p voltage) + (battery voltage*battery current)

Generated power by wind turbine = DC power/charge controller efficiency Coefficient of performance = Generated power*100/Wind power

THEORY:

The power in the wind can be derived from the Kinetic energy equation for wind flow. The power in the wind is proportional to:

- The area swept by the rotor
- The cube of the wind speed
- The air density - which varies with altitude

The formula used for calculating the power in the wind is shown below:
Power = (density of air x swept area x velocity cubed)/2
P = ½.ρ.A.V3
Where, P is power in watts (W), ρ is the air density (kg/m3),
A is the swept rotor area (m2), V is the wind speed (m/s)

The actual power that we can extract from the wind is significantly less than this figure suggests. The actual power will depend on several factors, such as the type of machine and rotor used the sophistication of blade design, friction losses, and the losses in the pump or other equipment connected to the wind machine. There are also physical limits to the amount of power that can be extracted realistically from the wind. It can be shown theoretically (Betz limit) that any windmill can only possibly extract a maximum of 59.3% of the power from the wind. In reality, coefficient of performance is lesser than betz limit. So, modifying the formula for 'Power in the wind' we can say that the power which is produced by the wind machine can be given by:
Pm = ½.ρ.A.V3. C
Where, Pm is power output(W) available from the generator,

Cp is the coefficient of performance of the wind machine.

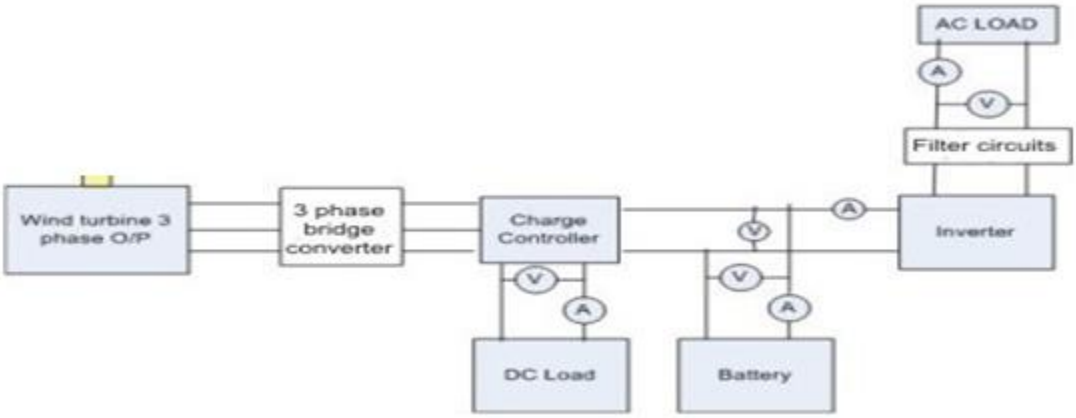
Cp is defined by,
Cp = (Rotor power)/(Dynamic power) and can also be expressed as,

C = 4a(1-a2),
Where, a is the fractional decrease in the wind velocity between the free stream and the rotor plane.

a= (U_1-U_2)/U_1 . U1 is the wind speed of the free stream at a distance from the rotor. U2 is the wind speed just near the rotor plane. The maximum theoretical Cp is determined by taking the derivative of the power coefficient with respect to a and setting it to zero, yielding

a=1/3, Thus: Cp,max= 16/27 = 0.5926, which is called as the betz limit. The practical value is always lesser than this value.

BLOCK DIAGRAM



TABULATION:

Efficiency of wind turbine =

S. No.	Wind speed (m/s)	Turbine Current (A)	Turbine voltage (V)	DC load current (A)	DC load voltage (V)	Inverter i/p current (A)	Inverter i/p voltage (V)	Wind power	Cp
1									
2									
3									
4									
5									

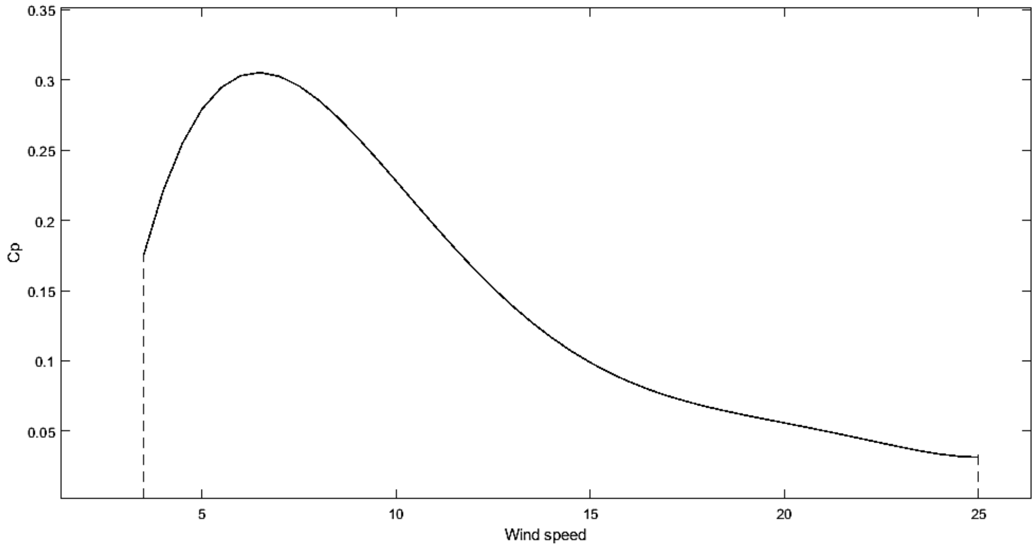
PRECAUTIONS:

1. Don't exceed the rated values

PROCEDURE:

1. Connections are made in Control board.
2. Set Wind speed
3. Note Wind speed
4. Switch Battery – ON, Mains – OFF, Inverter - ON
5. Switch on load (Full Load)
6. Switch on the load and note down the Voltage and current

MODEL GRAPH:



CALCULATION:

RESULT:

Thus the Evaluate the CP at different wind speeds and performance of wind generator is calculated. Also plot a curve between CP and Wind speed.

Ex. No.: 5
Date :

EXPERIMENT ON PERFORMANCE ASSESSMENT OF HYBRID (SOLAR-WIND) POWER SYSTEM

AIM:

To Evaluate the power of wind turbine and solar (HYBRID).

APPARATUS REQUIRED:

Sl. No.	Apparatus Name	Range	Quantity
1	Wind Generator PMSG (3 phase)	100W	1
2	Wind trainer kit	-	1
3	PV module	12 V, 165 W 5A	1
4	Solar PV trainer kit	-	1
5	Inverter module	600VA (10-15)V	1
6	Battery	12V, 40AH	1
7	Anemometer	-	1
8	LUX Meter	-	1
9	DC Lamp (Load)	9W	5
10	AC Lamp (Load)	40W	5
11	Connecting wires	-	As required

FORMULA USED:

power can be calculated by

P (electrical) = [(DC load voltage*DC load current) + (battery voltage*battery current)]*charge controller efficiency
OR
P (electrical) = [(inverter i/p voltage*inverter i/p current) + (battery voltage*battery current)]*charge controller efficiency

Wind speed will be measured with the help of anemometer which is placed just behind the turbine. Power in wind flow can be measured by following formula

P (wind) = ρ*A*V3/2

Power will be calculated at different wind speed and then coefficient of performance will be evaluated at different wind speed.

DC power at output of charge controller (DC power) = (DC load voltage*DC load current) + (battery voltage*battery current)
OR
DC power at output of charge controller (DC power) = (inverter i/p current*inverter i/p voltage) + (battery voltage*battery current)

Generated power by wind turbine = DC power/charge controller efficiency Coefficient of performance = Generated power*100/Wind power

Hybrid Power = DC power at output of wind turbine + DC power at output of Solar Panel

THEORY:

The power in the wind can be derived from the Kinetic energy equation for wind flow. The power in the wind is proportional to:

- The area swept by the rotor
- The cube of the wind speed
- The air density - which varies with altitude

The formula used for calculating the power in the wind is shown below:

Power = (density of air x swept area x velocity cubed)/2

P = ½.ρ.A.V3

Where, P is power in watts (W), ρ is the air density (kg/m3),

A is the swept rotor area (m2), V is the wind speed (m/s)

The actual power that we can extract from the wind is significantly less than this figure suggests. The actual power will depend on several factors, such as the type of machine and rotor used the sophistication of blade design, friction losses, and the losses in the pump or other equipment connected to the wind machine. There are also physical limits to the amount of power that can be extracted realistically from the wind. It can be shown theoretically (Betz limit) that any windmill can only possibly extract a maximum of 59.3% of the power from the wind. In reality, coefficient of performance is lesser than betz limit. So, modifying the formula for 'Power in the wind' we can say that the power which is produced by the wind machine can be given by:

Pm = ½.ρ.A.V3. C

Where, Pm is power output(W) available from the generator,

Cp is the coefficient of performance of the wind machine.

Cp is defined by,

Cp = (Rotor power)/(Dynamic power) and can also be expressed as,

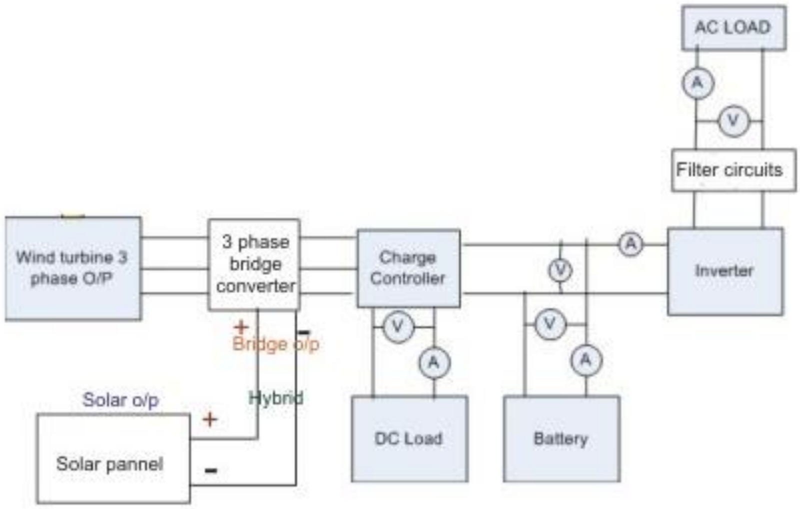
C = 4a(1-a2),

Where, a is the fractional decrease in the wind velocity between the free stream and the rotor plane.

a= (U_1-U_2)/U_1 . U1 is the wind speed of the free stream at a distance from the rotor. U2 is the wind speed just near the rotor plane. The maximum theoretical Cp is determined by taking the derivative of the power coefficient with respect to a and setting it to zero, yielding

a=1/3, Thus: Cp,max= 16/27 = 0.5926, which is called as the betz limit. The practical value is always lesser than this value.

BLOCK DIAGRAM



TABULATION:

Efficiency of Wind turbine =

S. No.	Wind speed (m/s)	Turbine Current (A)	Turbine voltage (V)	DC load current (A)	DC load voltage (V)	Inverter i/p current (A)	Inverter i/p voltage (V)	Wind power
1								
2								
3								
4								
5								
6								
7								

Efficiency of Solar Panel =

S. No.	SOLAR Lux	solar Current (A)	solar voltage (V)	DC load current (A)	DC load voltage (V)	Inverter i/p current (A)	Inverter i/p voltage (V)	Solar power
1								
2								
3								
4								
5								
6								
7								

Efficiency of Solar/Wind Hybrid =

S. No.	Hybrid Current (A)	Hybrid voltage (V)	DC load current (A)	DC load voltage (V)	Inverter i/p current (A)	Inverter i/p voltage (V)	Hybrid power
1							
2							
3							
4							
5							
6							
7							

PRECAUTIONS:

1. Readings for one set should be taken within 1-2 minutes (for indoor exp.) otherwise temperature of the module may vary as radiation source used is halogen lamp.
2. Always take radiation reading after module current and voltage readings.

PROCEDURE:

1. Connections are made in Control board.
2. Set radiation level
3. Note temperature level
4. Switch Battery – ON, Mains – OFF, Inverter - ON
5. Switch on load (Full Load)
6. Switch on the load and note down the Voltage and current
7. Connect wind and solar module in parallel and repeat the experiment.

CALCULATION:

RESULT:

Thus the power flow of the wind turbine and solar (HYBRID) system of DC and AC load with battery for the given module is calculated.

Ex. No.: 6
Date :

SIMULATION STUDY ON SOLAR PV ENERGY SYSTEM

AIM

To build, simulate, and analyze solar PV energy system using MATLAB under loaded conditions, and to understand the characteristic of solar PV energy system tem

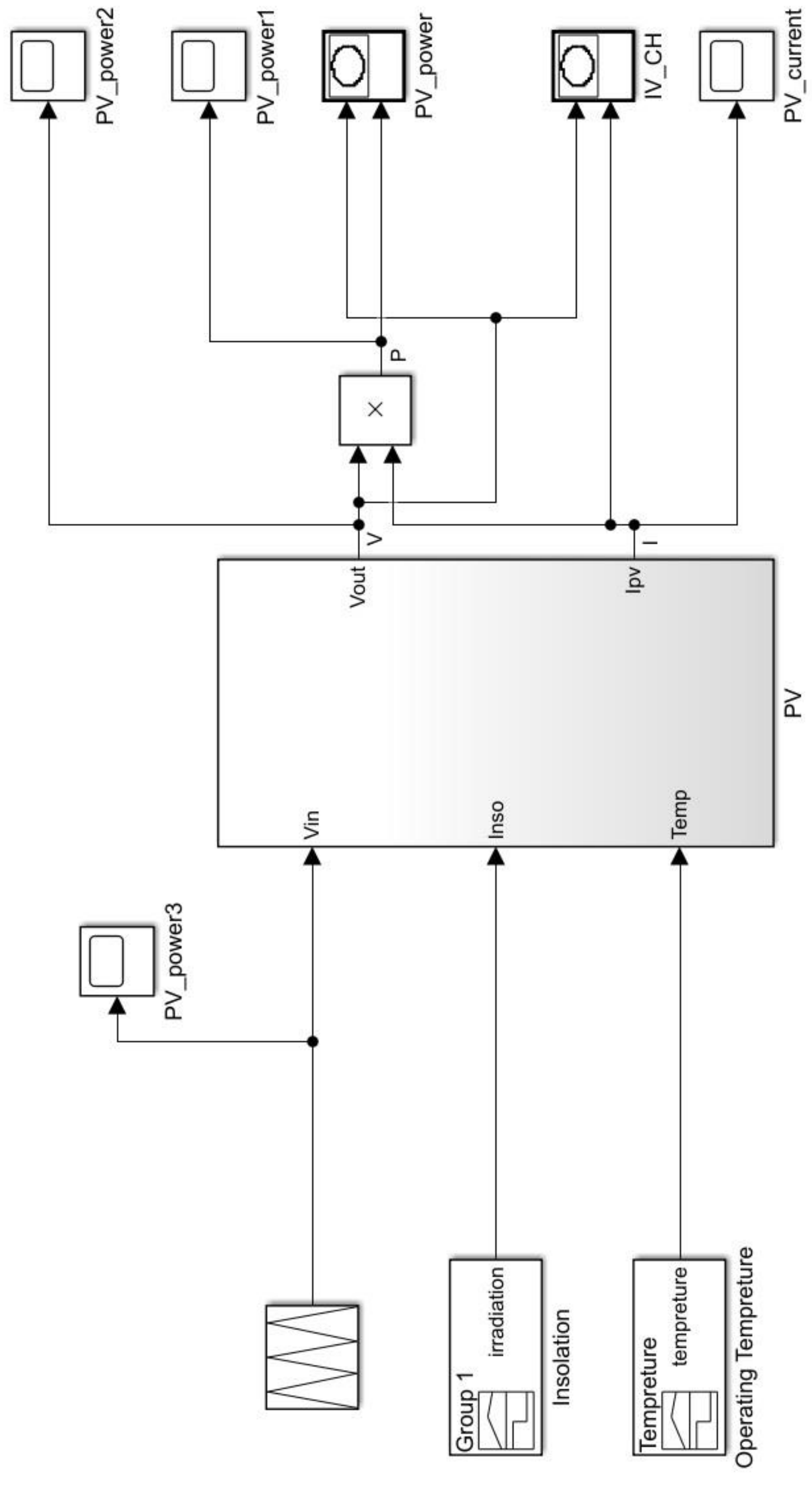
SOFTWARE REQUIRED

- MATLAB

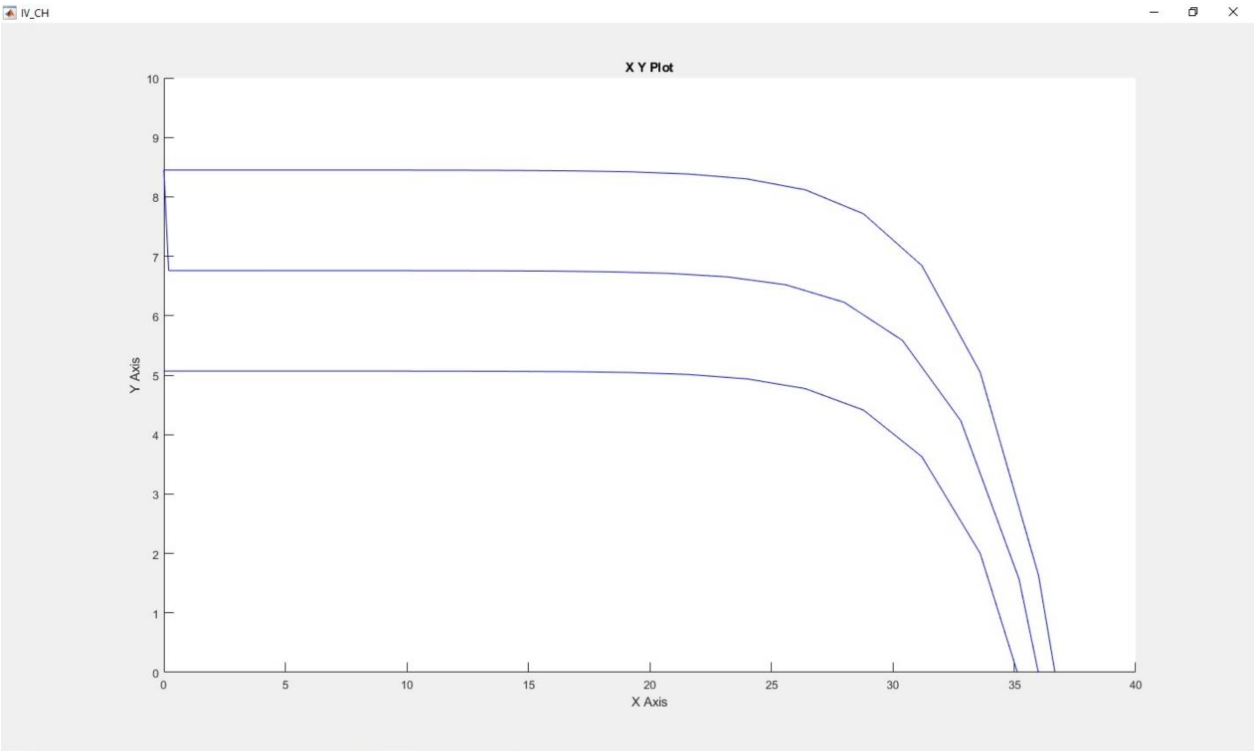
PROCEDURE

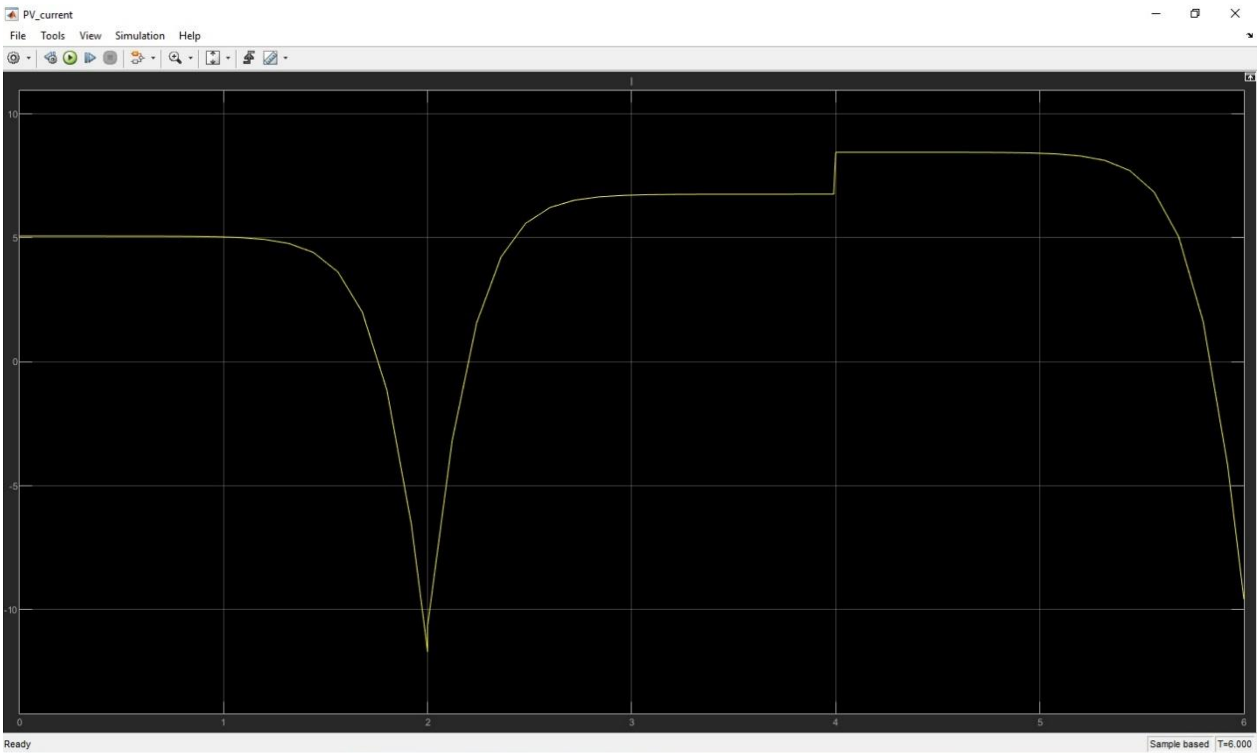
1. Design the MATLAB circuit for solar PV energy system
2. In scope, View the load current and Voltage.

SIMULINK MODEL



OUTPUT





RESULT

Thus the solar PV energy system was designed and analyzed using MATLAB

Ex. No.: 7
Date :

SIMULATION STUDY ON WIND ENERGY GENERATOR

AIM

To build, simulate, and analyze wind energy power system using MATLAB under loaded conditions, and to understand the characteristic of wind energy power system

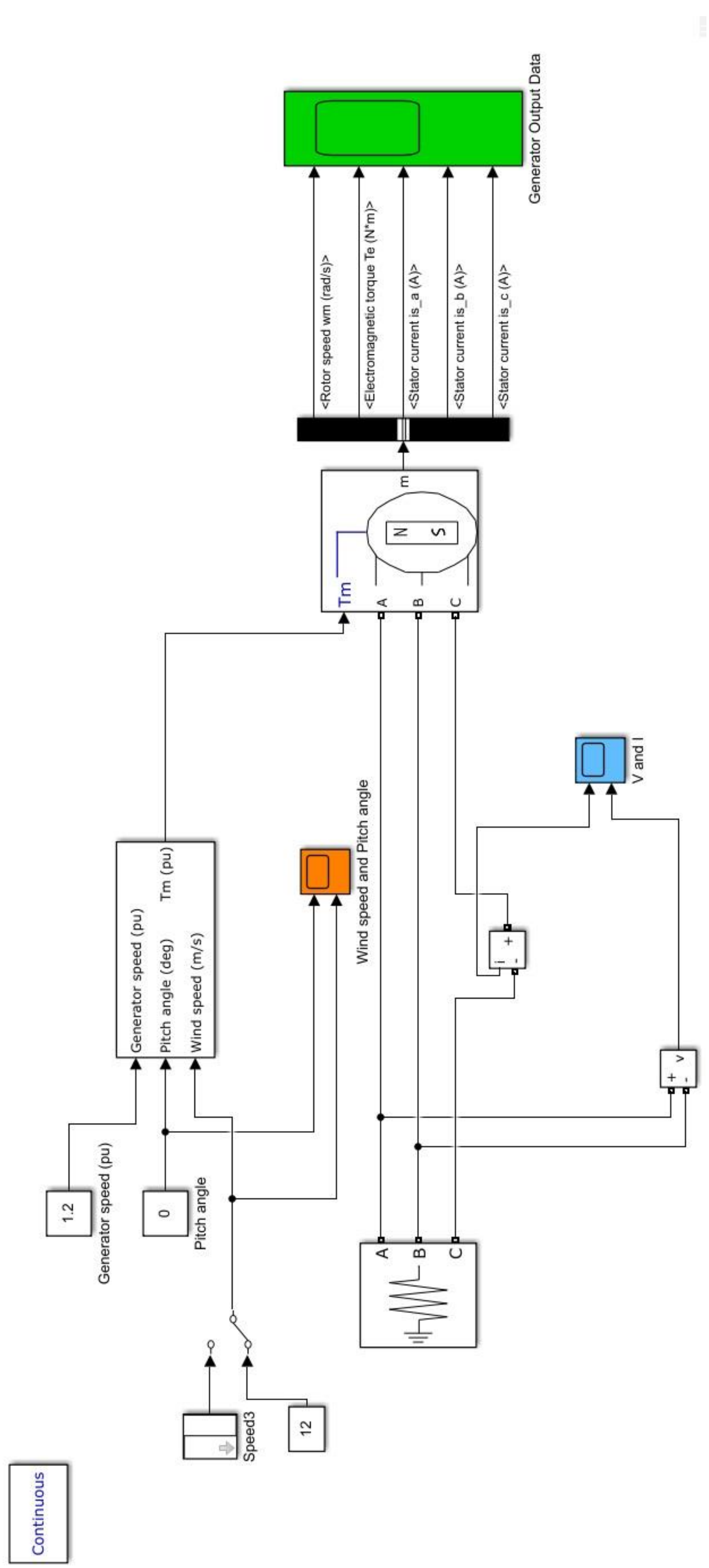
SOFTWARE REQUIRED

- MATLAB

PROCEDURE

1. Design the MATLAB circuit for wind energy power system
2. In scope, View the load current and Voltage.

SIMULINK MODEL



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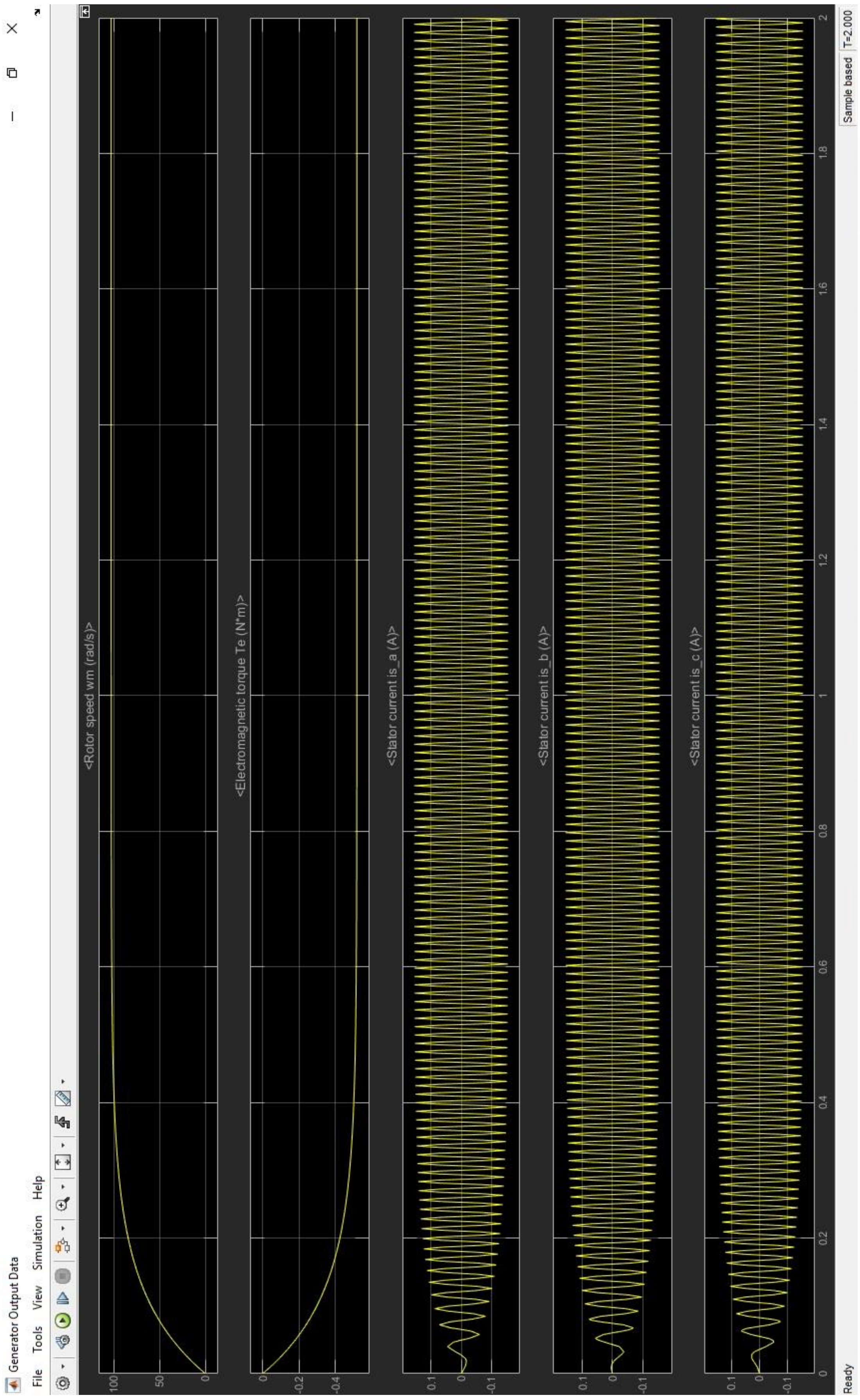


RESULT

Thus the wind energy power system was designed and analyzed using MATLAB

Ex. No.: 8
Date :

SIMULATION STUDY ON HYBRID (SOLAR-WIND) POWER SYSTEM.

AIM

To build, simulate, and analyze solar wind hybrid power system using MATLAB under loaded conditions, and to understand the characteristic of solar wind hybrid power system

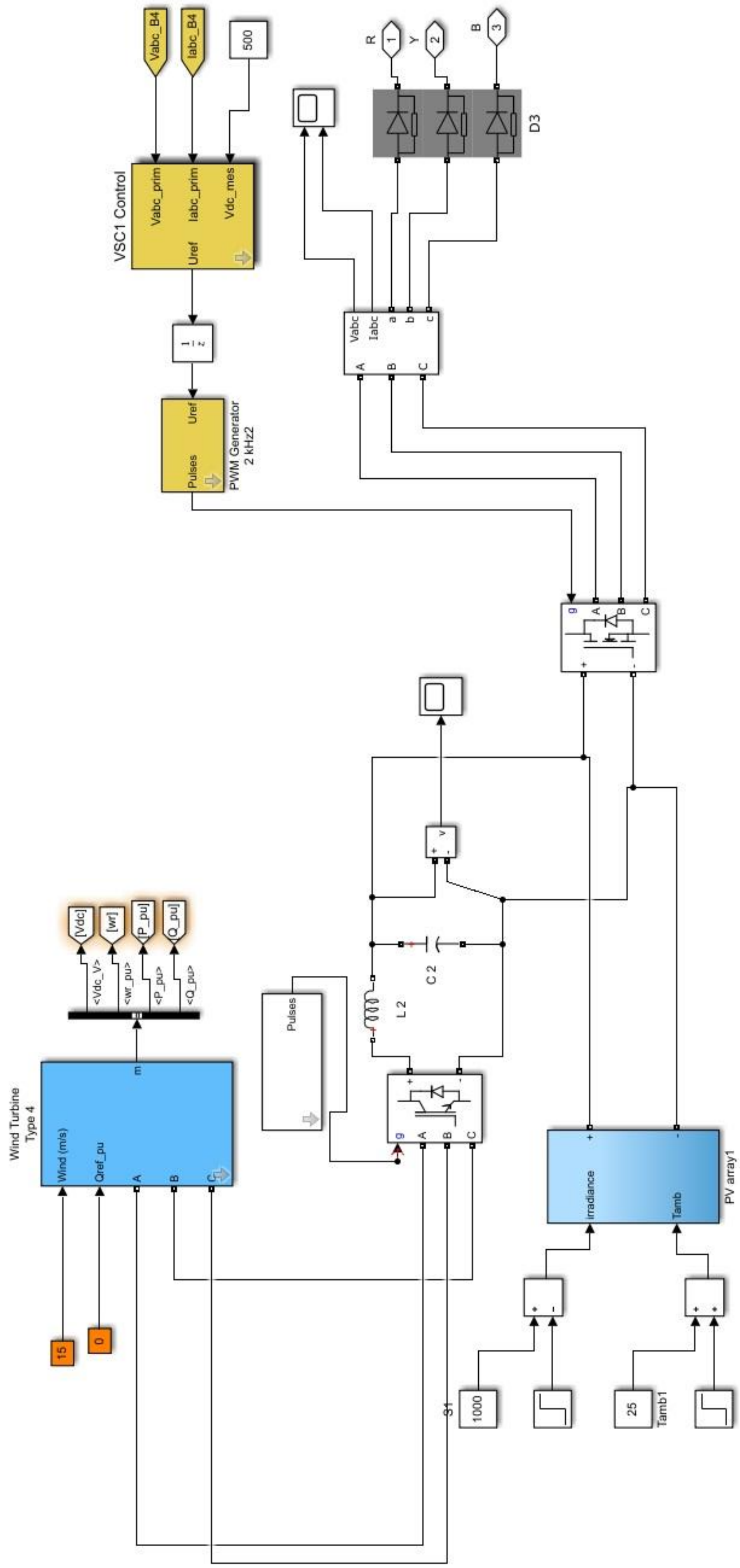
SOFTWARE REQUIRED

- MATLAB

Procedure (STAR connection)

1. Design the MATLAB circuit for solar wind hybrid power system
2. In scope, View the load current and Voltage.

SIMULINK MODEL



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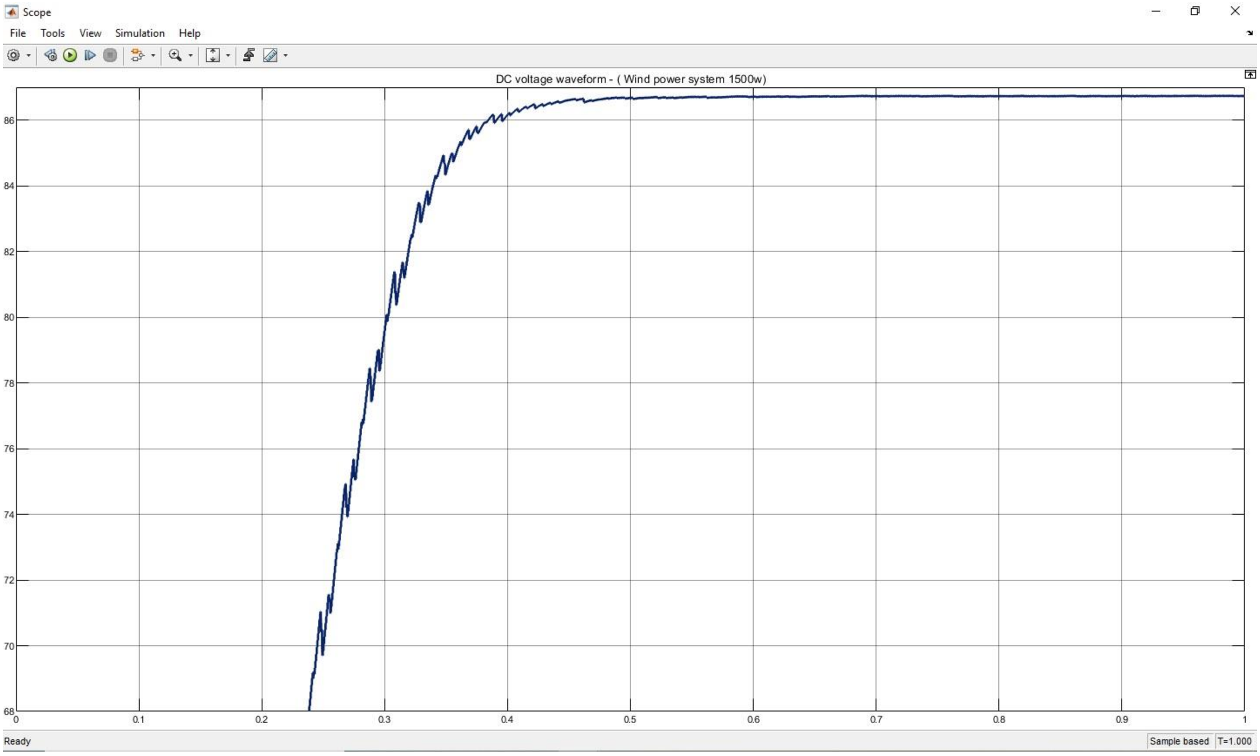
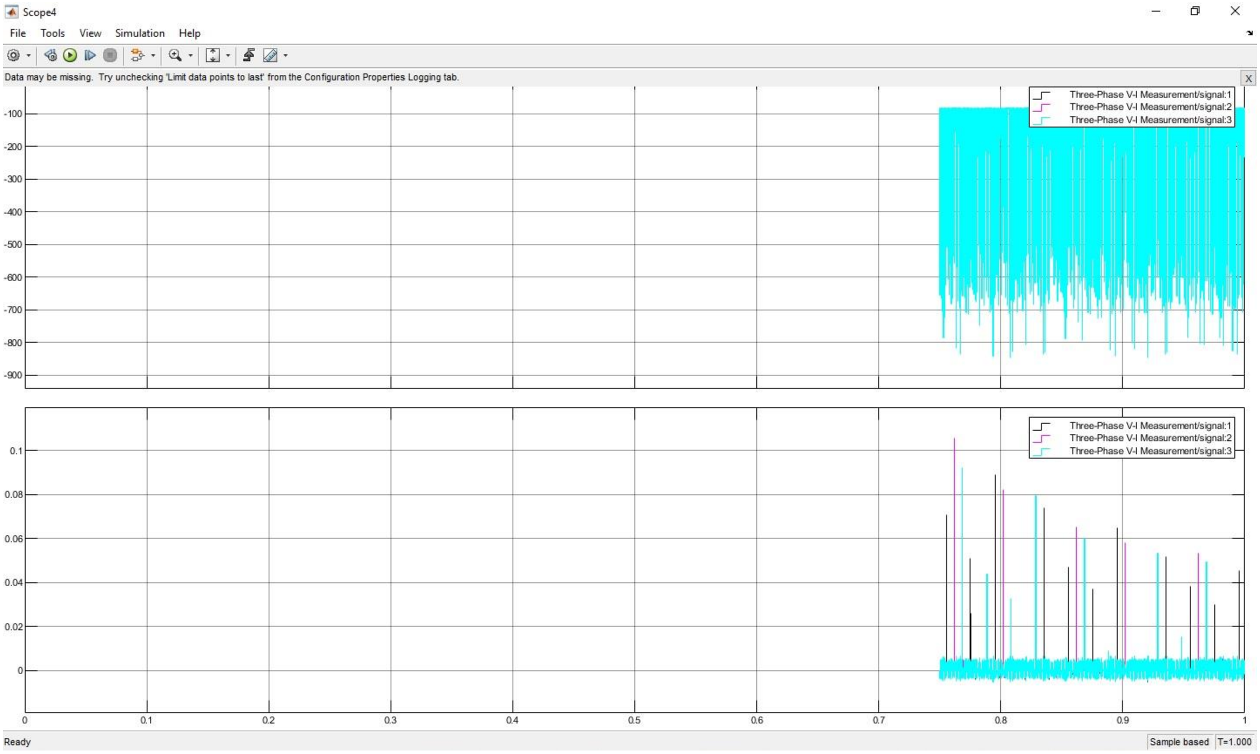




RESULT

Thus the solar wind hybrid power system was designed and analyzed using MATLAB software.

Ex. No.: 9
Date :

SIMULATION STUDY ON HYDEL POWER

AIM

To build, simulate, and analyze hydel power system using MATLAB under loaded conditions, and to understand the characteristic of hydel power system

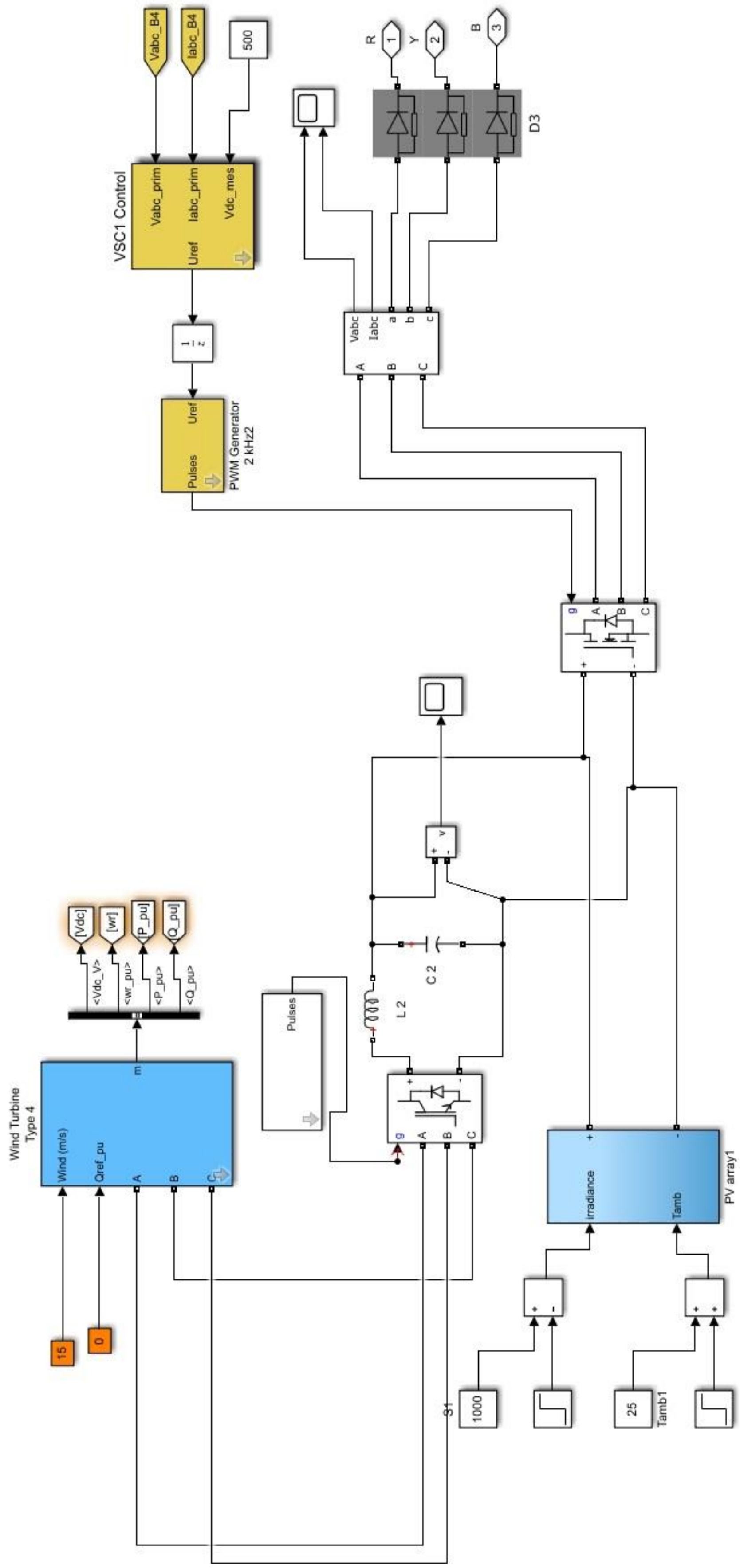
SOFTWARE REQUIRED

- MATLAB

Procedure (STAR connection)

1. Design the MATLAB circuit for hydel power system
2. In scope, View the load current and Voltage.

SIMULINK MODEL



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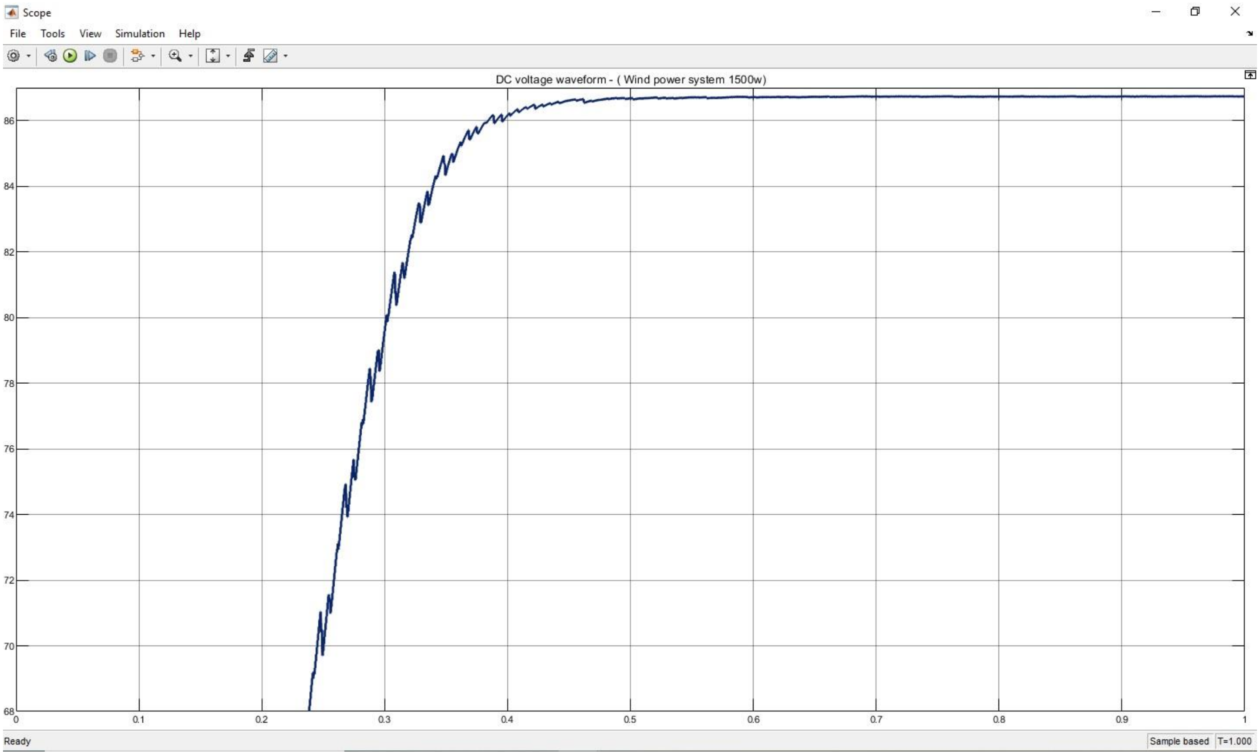
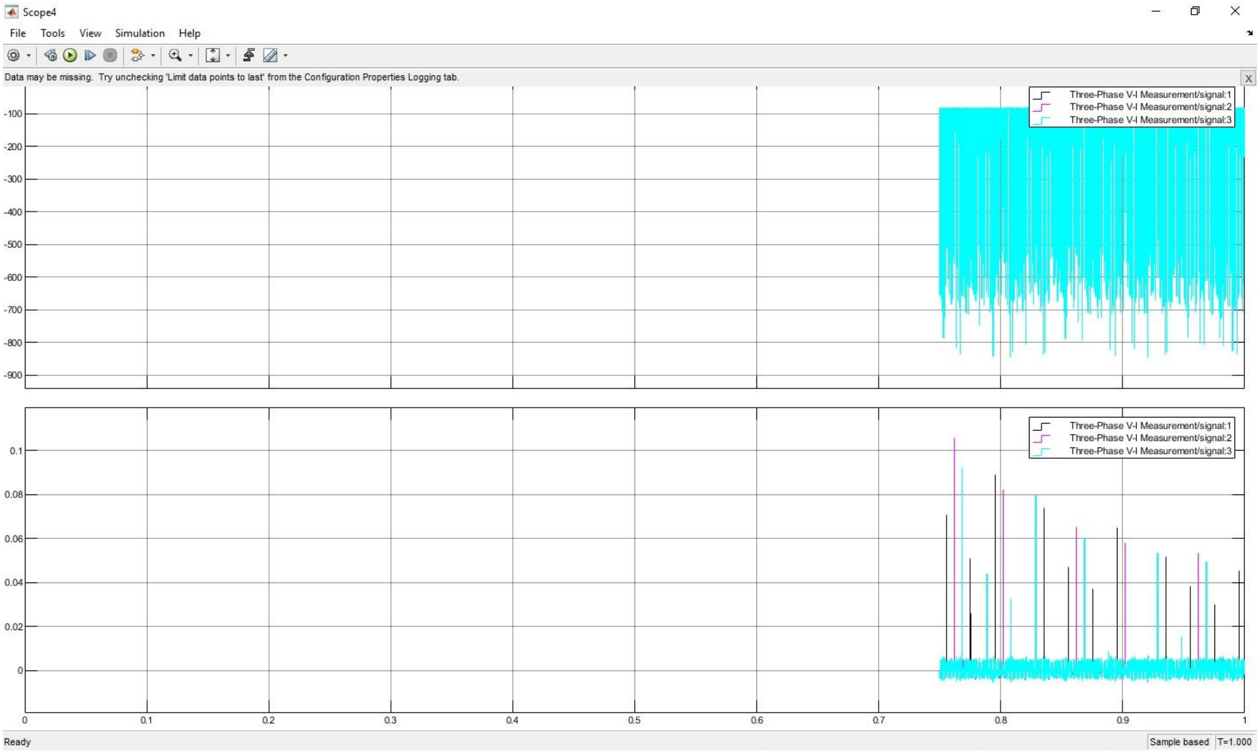




RESULT

Thus the hydel power system was designed and analyzed using MATLAB software.

Ex. No.: 10
Date :

SIMULATION STUDY ON PERFORMANCE ASSESSMENT OF 100W FUEL CELL

AIM

To build, simulate, and analyze Fuel cell system using MATLAB under loaded conditions, and to understand the characteristic of fuel cell system

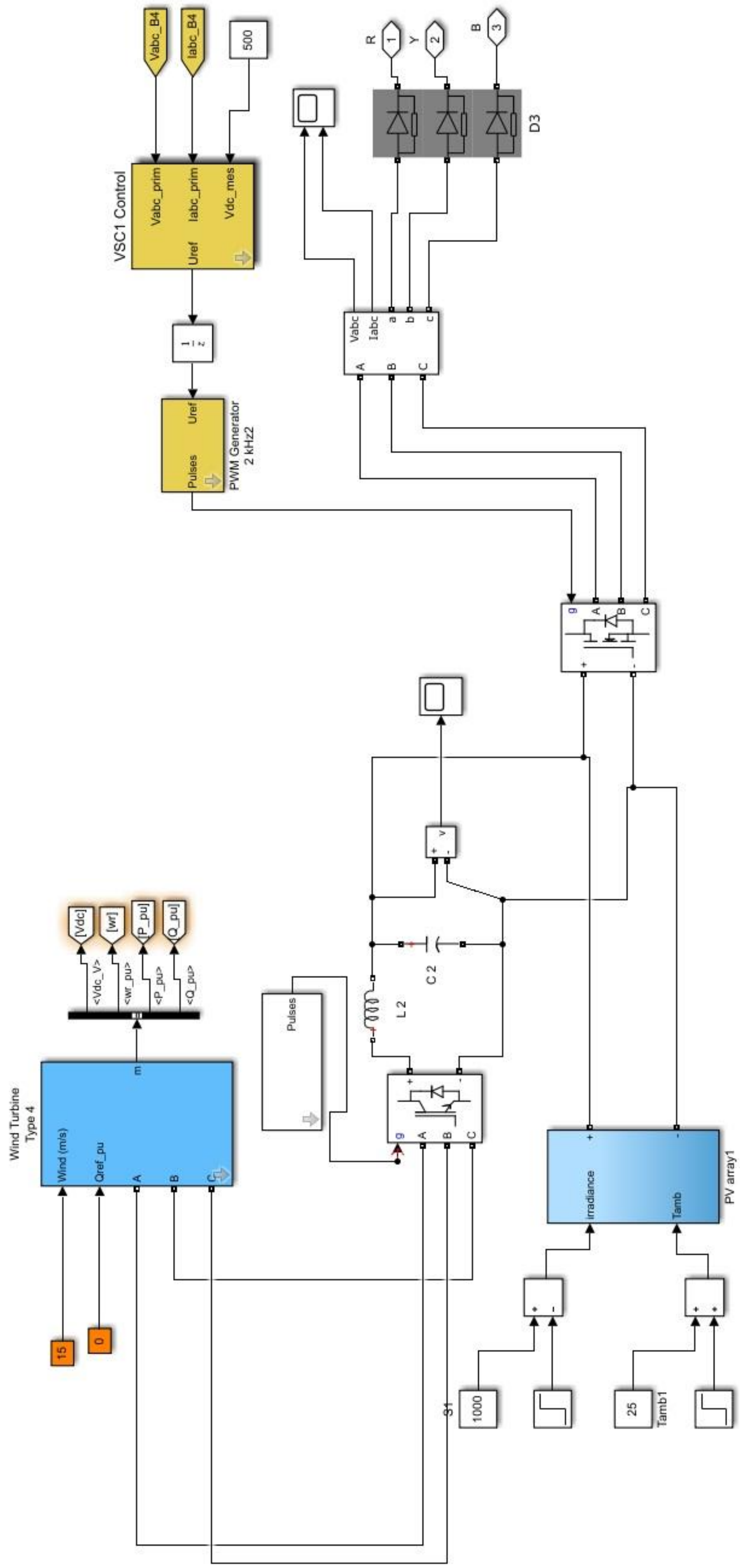
SOFTWARE REQUIRED

- MATLAB

Procedure (STAR connection)

1. Design the MATLAB circuit for Fuel cell system
2. In scope, View the load current and Voltage.

SIMULINK MODEL



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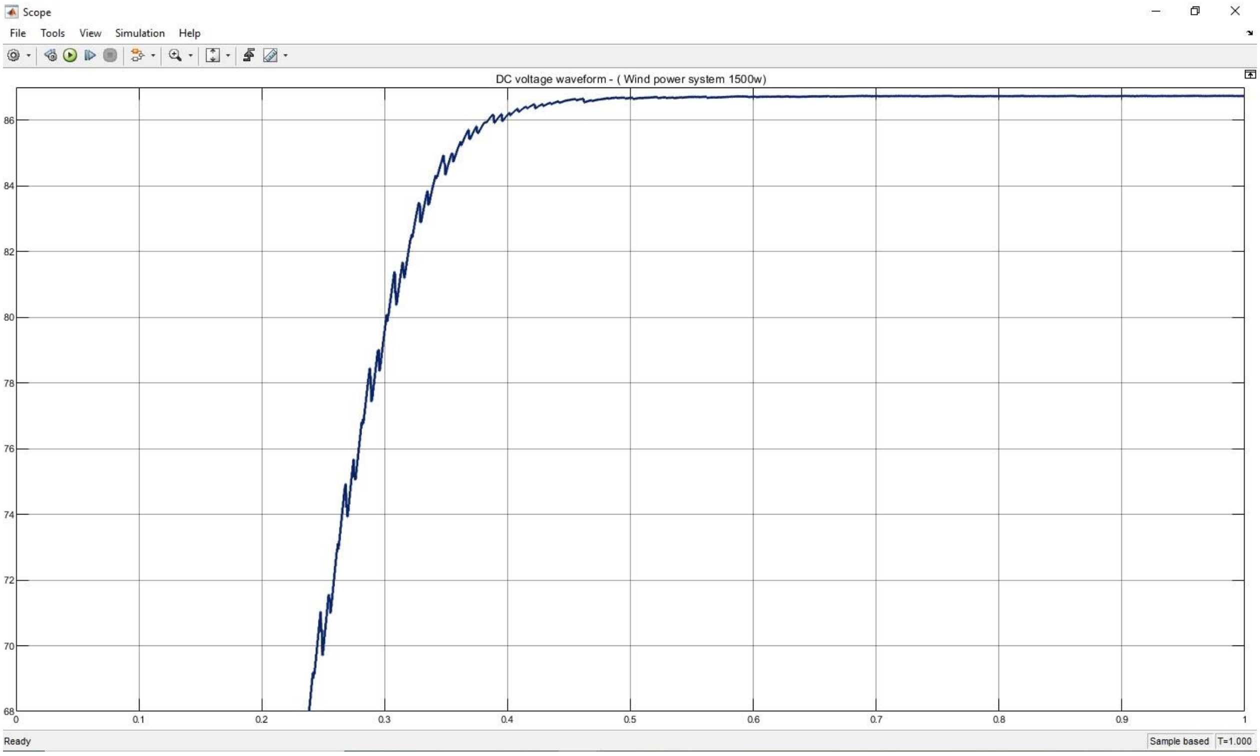
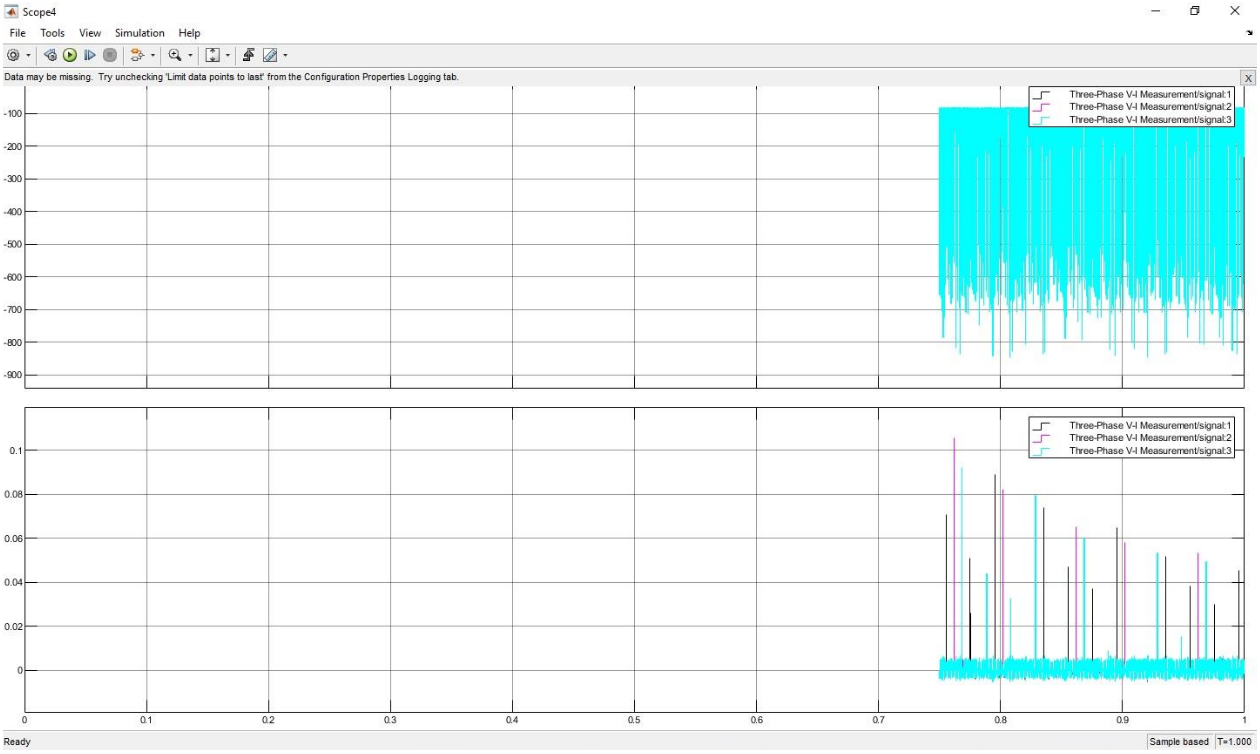




RESULT

Thus the Fuel cell system was designed and analyzed using MATLAB software.

Ex. No.: 11
Date :

SIMULATION STUDY ON INTELLIGENT CONTROLLERS FOR HYBRID SYSTEMS

AIM

To build, simulate, and analyze intelligent controller solar wind hybrid power system using MATLAB under loaded conditions, and to understand the characteristic of solar wind hybrid power system

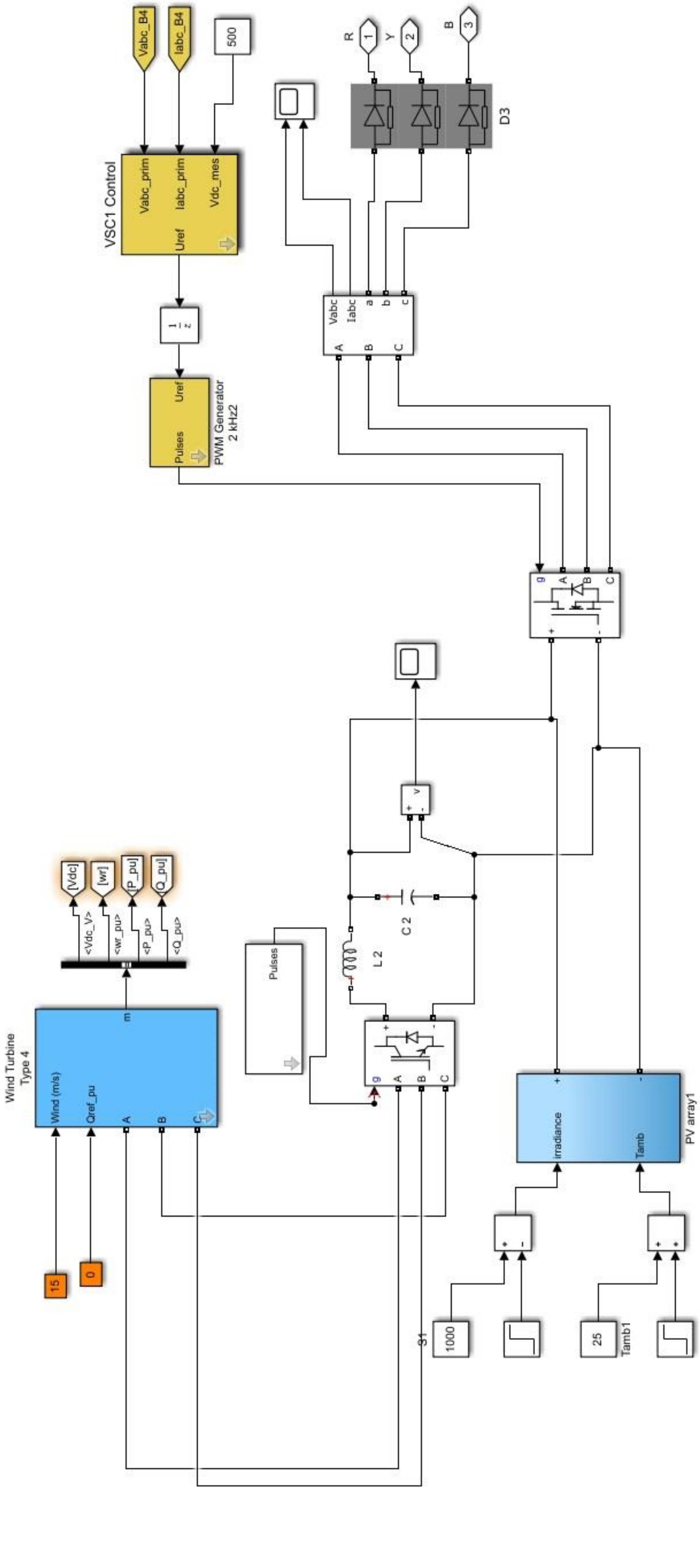
SOFTWARE REQUIRED

- MATLAB

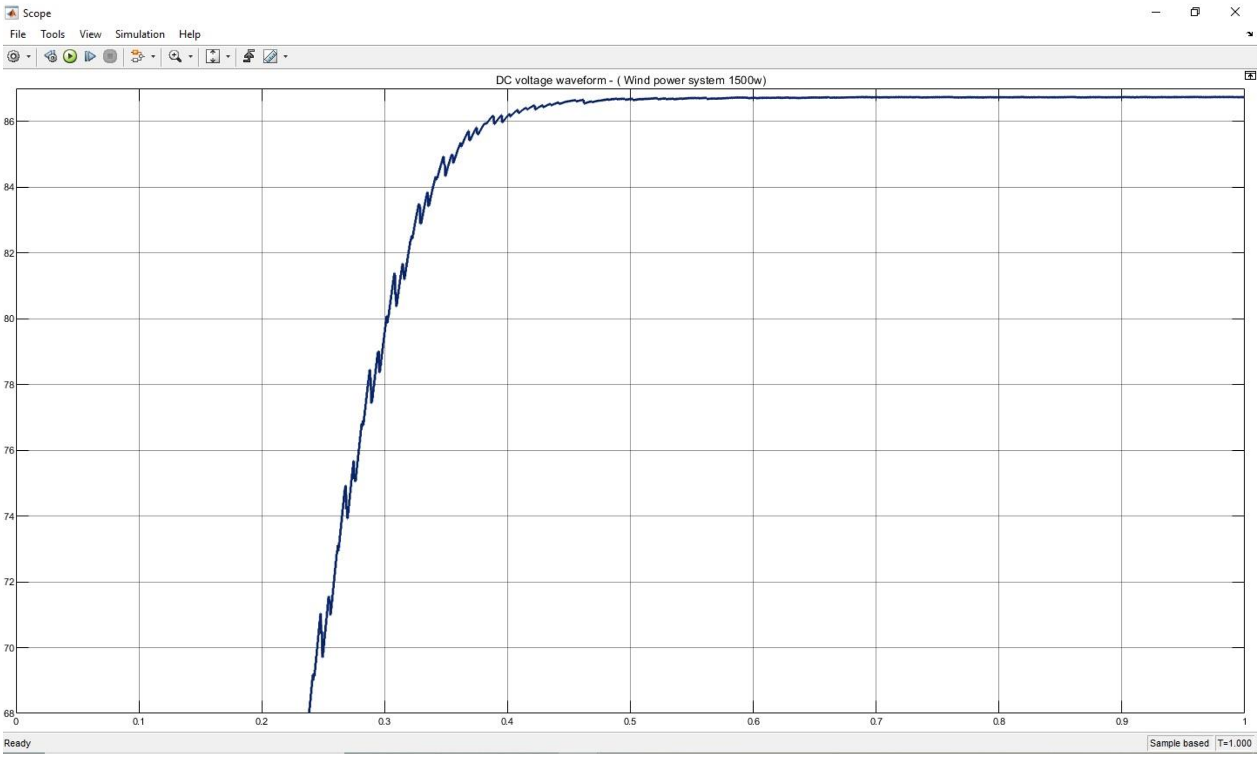
Procedure (STAR connection)

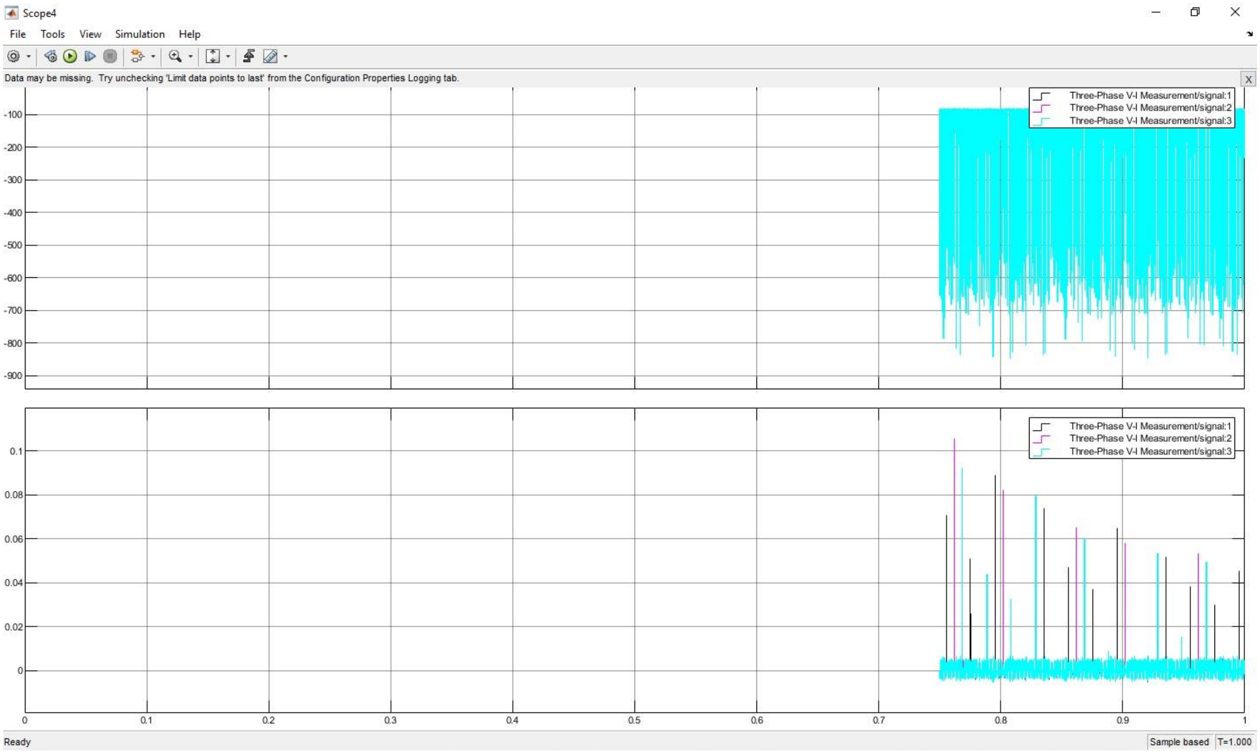
1. Design the MATLAB circuit for intelligent controller solar wind hybrid power system
2. In scope, View the load current and Voltage.

SIMULINK MODEL



OUTPUT





RESULT

Thus the intelligent controller solar wind hybrid power system was designed and analyzed using MATLAB software.