Code : KTEHB520N-AE100

HYBRID POWER CONVERSION EXPERIMENTAL EQUIPMENT
Ver.1.0.0

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1. Solar/Wind Hybrid Electric Conversion Test Equipment

1-1. Introduction

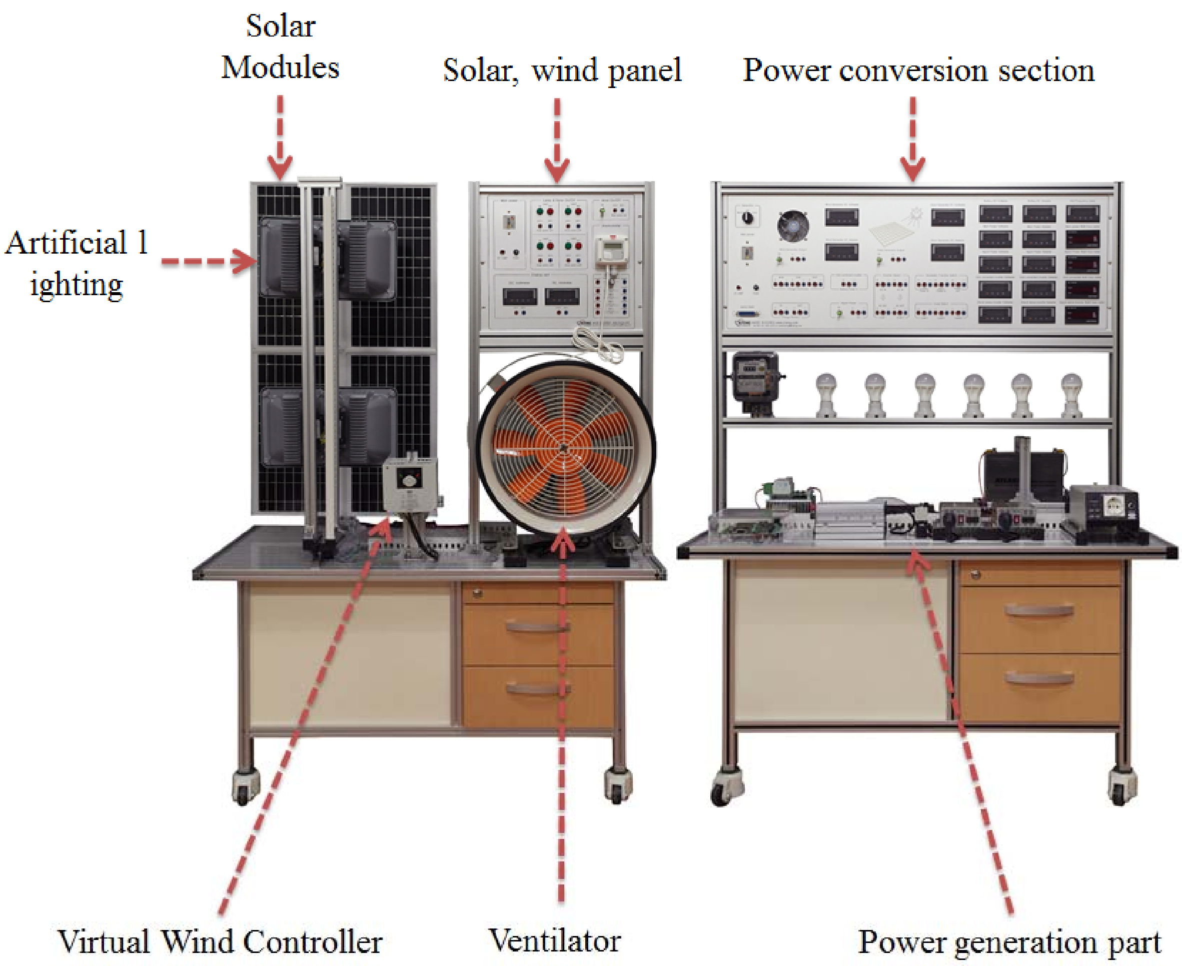
Solar/wind hybrid electric conversion test equipment, KTE-HB520N, consists of a solar generator with capacity of 80W, a wind generator with capacity of 60W, and KTE-CP520.

The solar/wind hybrid generators produce electricity needed for the experiment and the electric conversion test equipment processes the produced electricity into a useful electricity for linking systems and operation of general loads. Moreover, the electric conversion test equipment uses an automatic controller to arrange a controller circuit for conducting control test of the generator system with different capacities.

1-2. Composition of Test Equipment

(1) Compositions of Hybrid System

(2) Solar and Wind Generators



[Solar module, artificial lighting, wind generator, virtual wind producer, test components of KTE-CP520 system]

2. Characteristics of Hybrid Electric Conversion Test Equipment

2-1. Solar Generator

Solar generator can produce up to 80W of electricity using 4 20W modules. It can generate electricity indoors as well using an artificial lighting.

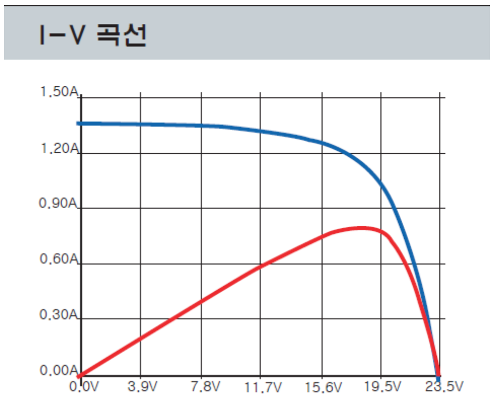
(1) Solar Module

It consists of solar cells, the minimum unit of solar cell that converts solar energy to electrical energy. It produces electricity with solar modules in arrays of parallel or series .

[Diagram 2-1] Solar Module

※ Specifications

- Max. Power: 20W
- Max. Power Voltage: 19.5V
- Max. Power Current: 1.26A
- Open Circuit Voltage: 23.5V
- Short Circuit Current: 1.34A
- STC: Insolation 1000W/m^2, atmospheric mass AM1.5, temperature 25℃



The solar module consists of solar cells, the minimum unit of solar cell that converts solar energy to electrical energy. It produces electricity with solar modules in arrays of parallel or series. This module is used for testing solar generation with single crystal silicon and has an efficiency of 13.98%.

- Solar generator can be used indoors using artificial lighting. 4 300W lamps that can be moved back and forth allows experiments with varying insolation.

※ Specifications
- Type: Halogen Lamp
- Capacity: 300W
- Color Temperature: 2900K
- Color Rendition: Ra=100

[Diagram 2-2] Artificial Lighting

It has halogen lamps that can be used in cases where solar light is unavailable. Using the artificial lighting for solar generation test gives about 11% of electricity generation amount of that acquired using natural solar light.

2-2. Wind Generator

Wind generator has a capacity of 60W and it uses virtual wind producer, which allows precise control of wind speed, to test the performance of wind generator.

(1) Wind Generator

※ Specification
- Rotor Diameter: 510mm
- Wind Speed: 2.6m/s
- Volatage: DC 12V
- Electricity Yield:
  Generates 6W/h at 5.25m/s
  Generates 25W/h at 9.8m/s
  Generates 80W/h at 20.6m/s

[Diagram 2-3] Wind Generator

(2) Virtual Wind Producer

[Diagram 2-4] Wind Producer

※ Specification
- Power: Single-phase 220V, 60Hz
- Fan Size: 370cm
- Electricity Consumption: 400W
- Max. Wind: 6,060CMH

It produces virtual wind for the wind generator to operate and the wind speed can be controlled with an inverter.

[Diagram 2-5]
Virtual Wind Controller

* Specification
- Voltage: Single phase, 200 ~ 240VAC ± 10%,
- Input Frequency: 50 / 60Hz ± 5%
- 1.2KW rated output motor control
- Over load Limit:150%rated current for 60 seconds
- Output Rated frequency: 1 ~ 400Hz

(3) Control Panel of the Generating System

It is a control panel for conducting a test with the solar and wind generators. You can wire, control and test the basing conditions of solar and wind generators such as the parallel/series output test with solar generation and wind speed test for wind generator.

1) Control Panel

[Diagram 2-6] Control Panel

※ Specification
- Circuit Breaker: 30A
- Push Button: 8EA
- Toggle Switch: 1EA
- DC Voltameter: 1EA
- DC Ammeter: 1EA
- Anemometer: 1EA
- Resistor: Variable Resistor (1KΩ), 100Ω(4EA)

2) Wind/Temperature Gauge

[Diagram 2-7]
Wind/Temperature Gauge

※ Specification
- Measuring Range: Wind speed 0~30m/s, Temeprature -20~80℃
- Resolution: 0.1m/s, 0.1℃
- Uncertainty: ±0.3m/s, ±0.4℃
- Unit: m/s, fpm, ℃˚F

It measures the wind speed depending on the change in the wind power by the virtual wind producer and measures temperature necessary for calculating the efficiency of the solar module.

3) Solar/Wind Output

[Diagram 2-8] Output

※ Specification
- Solar Output Port: 4EA
- WInd Output Port: 1EA

Output ports of 4 20W solar modules and 60W wind generator are arranged on the control panel for user to easily conduct tests with parallel/series connections using banana jack.

2-3. Characteristics of Components of Hybrid Test System

(1) This system is a registered for patent (No. 10-2010-0031281) as complex electric conversion system for education purposes and it includes the test equipment and procedures for relevant experiments.

(2) You can use it for electric conversion test so that the new reusable energy electricity generated by the solar and wind generator can be used.

(3) You can use it for creating a basic sequence circuit related to solar generation using electric cells and conducting tests with it.

(4) You can connect it with SQ or PLC equipments to create parallel/series controller circuit, load electricity input circuit, automatic convertible circuit for electricity cut or discharge, and inverter system circuit.

(5) It is a console type, which is useful for moving experiments.

(6) To reduce circuit breakage time, the wiring of control panel is arranged with round ports and banana jacks.

(7) You can use the charging controller to safely store and use the electricity generated by solar and wind generators.

(8) You can convert electricity from solar/wind generator or generally used electricity into AC power using Stand-alone inverter or Grid Connection inverter.

(9) It can be connected with (KTE-DA100M) monitoring test equipment to conduct a more efficient solar generation test.

(10) The system is designed to allow performing tests using the generally used electricity, considering the cases without sun light or wind.

(11) The control system operates at 24V and it has a basic protection system using protective fuse.

(12) It is designed for easy inspection on internal circuit and maintenance with protection against heat.

3. Composition of Hybrid Test Equipment

3-1. Composition of Controller of Test Equipment

The hybrid test equipment consists of generator and controller parts and the solar generator system can be arranged using banana jacks on the controller. Also, training with solar generators and relevant sequence exercises can be conducted using the basic sequence cells and the equipment is designed so that its users can acquire the AC/DC voltage, current, power and other fundamental information on the system operation. Below diagram shows the composition of the control panel.

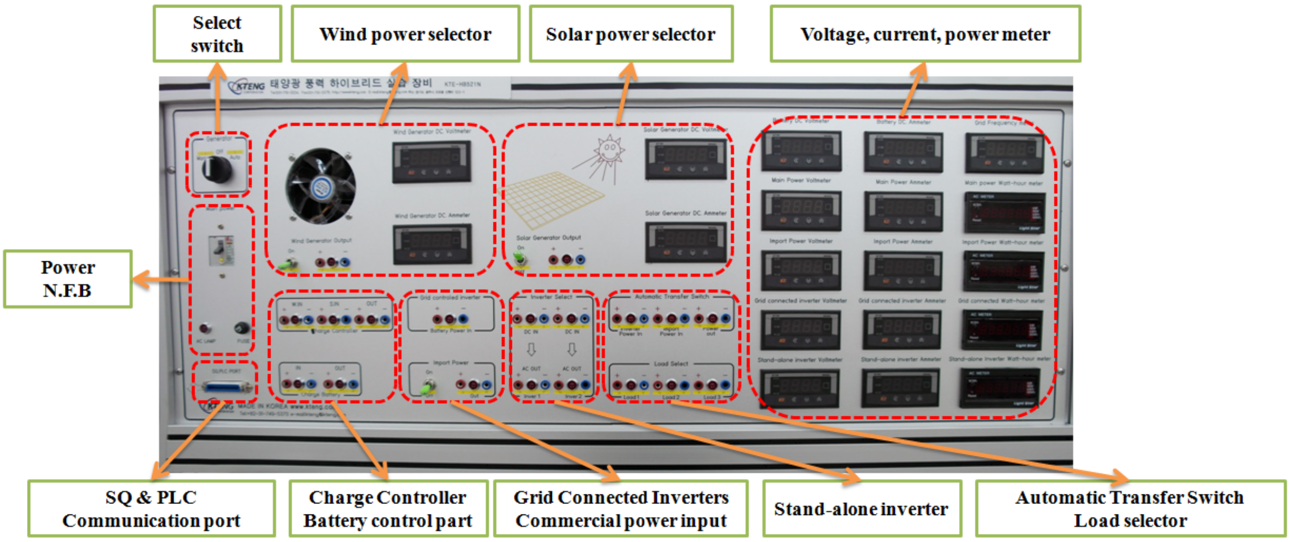


Diagram 3-1 Composition of Control Panel

(1) Power supply, communication port, manual/automatic mode switch

A. Power switch and fuse

* Model: 32GRhc, 1EA
* Voltage: AC 110/220V
* Minimum cell: 2P2E, single-phase
* Current: 30A
* Break current: 1.5KA
* Reception current: 30mA

Diagram 3-2 Earth Leakage Breaker

* AC LAMP(1EA): 24V Red Lamp
* FUSE(1EA) : 250V, 30A

Diagram 3-3 Fuse & Lamp

The earth leakage breaker is a switch that controls the main power of the system to protect electrical overstress. In case of electrical leakage, short circuits, overuse of the equipment or machinery and other overflow of current that surpasses the rated current, the breaker is turned OFF.

Once you turn the breaker ON, AC Lamp will turn on and in preparation for possible malfunctioning of the device, the breaker is designed to be supplied with power through fuse.

B. Communication Port (SQ, PLC, etc.)

You can connect 7000SQ or 7000PLC to eSQ or PLC ports to conduct remote control cable-controlled tests. The SQ and PLLC, connected with the electric conversion test equipment, have no separate power supplier and operate with the power from the communication cable. They are used for education on the basic sequence or PLC.

(2) Information Indication

A. Solar/Wind Generator Power Indication

Diagram 3-5 Solar cell voltage, current indicator, wind speed/current gauge

It displays the voltage and current values of electricity generated by the solar generator and that generated by the wind generator.

B. Generated Electricity Indication

Diagram 3-6 Inverter, commercial electricity, battery, main power generation indicator

(a) Battery Voltmeter – Output voltage of battery

(b) Battery Ammeter - Output current of battery

(c) Grid Frequency meter – Frequency indication

(d) Main Power Voltmeter – Voltage indication of main power

(e) Main Power Ammeter - Current indication of main power

(f) Main Power Watt-Hour meter – Power of main power indication

(g) Import Power Voltmeter – Voltage indication of commercial electricity

(h) Import Power Ammeter – Current indication of commercial electricity

(i) Import Power Watt-Hour meter – Power indication of commercial electricity

(j) Grid Connected Inverter Voltmeter – Voltage indication of Grid Connection inverter

(k) Grid Connected Inverter Ammeter – Current indication of Grid Connection inverter

(l) Grid Connected Inverter Watt-Hour meter – Power indication of Grid Connection inverter

(m) Stand-alone Inverter Voltmeter – Voltage indication of Stand-alone inverter

(n) Stand-alone Inverter Ammeter – Current indication of Stand-alone inverter

(o) Stand-alone Inverter Watt-Hour meter – Power indication of Stand-alone inverter

(3) Composition of the Solar Generator System

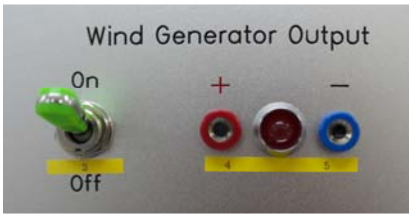
A. Solar Generator Output

Diagram 3-7 Power Switch and Output Terminal of the Solar Generator

* Toggle Switch(1ea) : Power controller of the solar generator
* [+]Terminal 1EA
* [-]Terminal 1EA
* Terminal Lamp 1EA

The Toggle Switch on Solar Generator Output is used for turning the generator on or off. When the toggle switch is turned on, 24V signal is produced from the output terminal and the lamp is turned on. Create circuit by connecting banana jack to S. IN of charge controller on the output terminal of the Solar Generator Output.

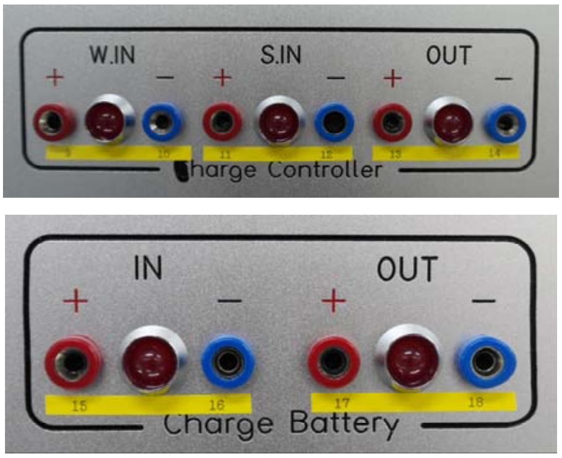
B. Wind Generator Output



* Toggle Switch(1ea) : Power controller of the wind generator
* [+]Terminal 1EA
* [-]Terminal 1EA
* Terminal Lamp 1EA

Diagram3-8 Power Switch and Output Terminal of the Wind Generator

C. Charge controller



* Charge Controller Terminal: Networked with the internal charge controller of the system
* Charge Battery Terminal: 12V 2EA Composes of parallely connected capacitors

Diagram3-9 Input and Output Terminal of Charge controller

(1) Charge Controller: Use banana jacks to connect (+) and (-) outputs with the (+) and (-) terminals of W.IN on Charge Controller for wind generator and reconnect the outputs to the (+) and (-) terminals of S.IN on Charge Controller for solar generator. The OUT terminal.

(2) Charge Battery: Connect OUT (+) and (-) terminals of Charge Controller with the IN (+) and (-) terminals of Charge Battery. The output can be received from the OUT terminal of Charge Battery.

D. Charge Battery

* [+]Terminal 2EA
* [-]Terminal 2EA
* Terminal Lamp 2EA

Diagram 3-10 Input and Output Terminal of the Charge Battery

Once you connect the output terminal of Charge controller with the input terminal of Charge Battery using banana jack, a constant 12V electricity from solar energy is saved in the battery. Use banana jack to connect output terminal of charge battery with input terminal of inverter.

E. Import power

* Toggle Switch 1EA
* [+]Terminal 1EA
* [-]Terminal 1EA
* Terminal Lamp 1EA

Diagram 3-11 Power Switch and Output Terminal of Import Power

In case of bad weather conditions or at nights, when solar generating is unavailable, you can conduct tests using the general commercial electricity. Connect the output terminal of import power with the input terminal of ATS using banana jack and turn the switch ON to use commercial electricity for load test.

F. Grid connected inverter

* [+]Terminal 1EA
* [-]Terminal 1EA
* Terminal Lamp 1EA

Diagram 3-12 Terminals of Grid Connected Inverter

You can use the terminals, which allows you to grid-connect the battery electricity with commercial electricity, to supply generated electricity to Korea electric power plant.

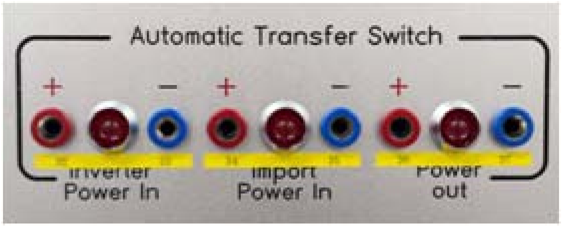
G. Inverter (Conversion from DC to AC)

* DC [+]Terminal 2EA
* DC [-]Terminal 2EA
* AC [+]Terminal 2EA
* AC [-]Terminal 2EA
* Terminal Lamp 4EA

Diagram 3-13 Inverter Select Terminal

Once you connect the output terminal of Charge Battery with the input terminal of Inverter using banana jack, 12V DC will be converted into 220V of AC. Connect otuput terminal of AC220V with input terminal of ATS.

H. Automatic Transfer Switch(ATS)

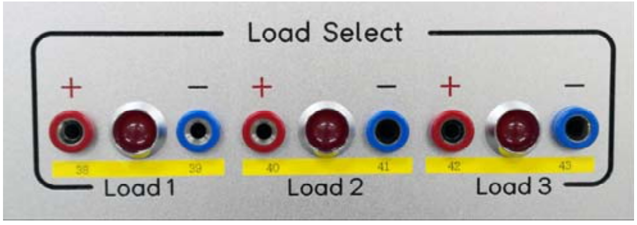


* [+]Terminal 3EA
* [-]Terminal 3EA
* Terminal Lamp 3EA

Diagram 3-14 Inverter of ATS & Input and Output Terminals of Commercial Electricity

To prepare independent solar generation system, connect output terminal of inverter with input terminal of ATS using banana jack and create load at output terminal of ATS. If you are using commercial electricity for the test, connect output terminal of import with input terminal of import power of ATS using banana jack and create load at otuput terminal of ATS. On an inverter system, the load operates immediately, but when you are using commercial eletricity, 30 seconds of time delay occurs. In other words, load arranged at the input terminal of import power on ATS starts operating after 30 seconds.

I. Load select

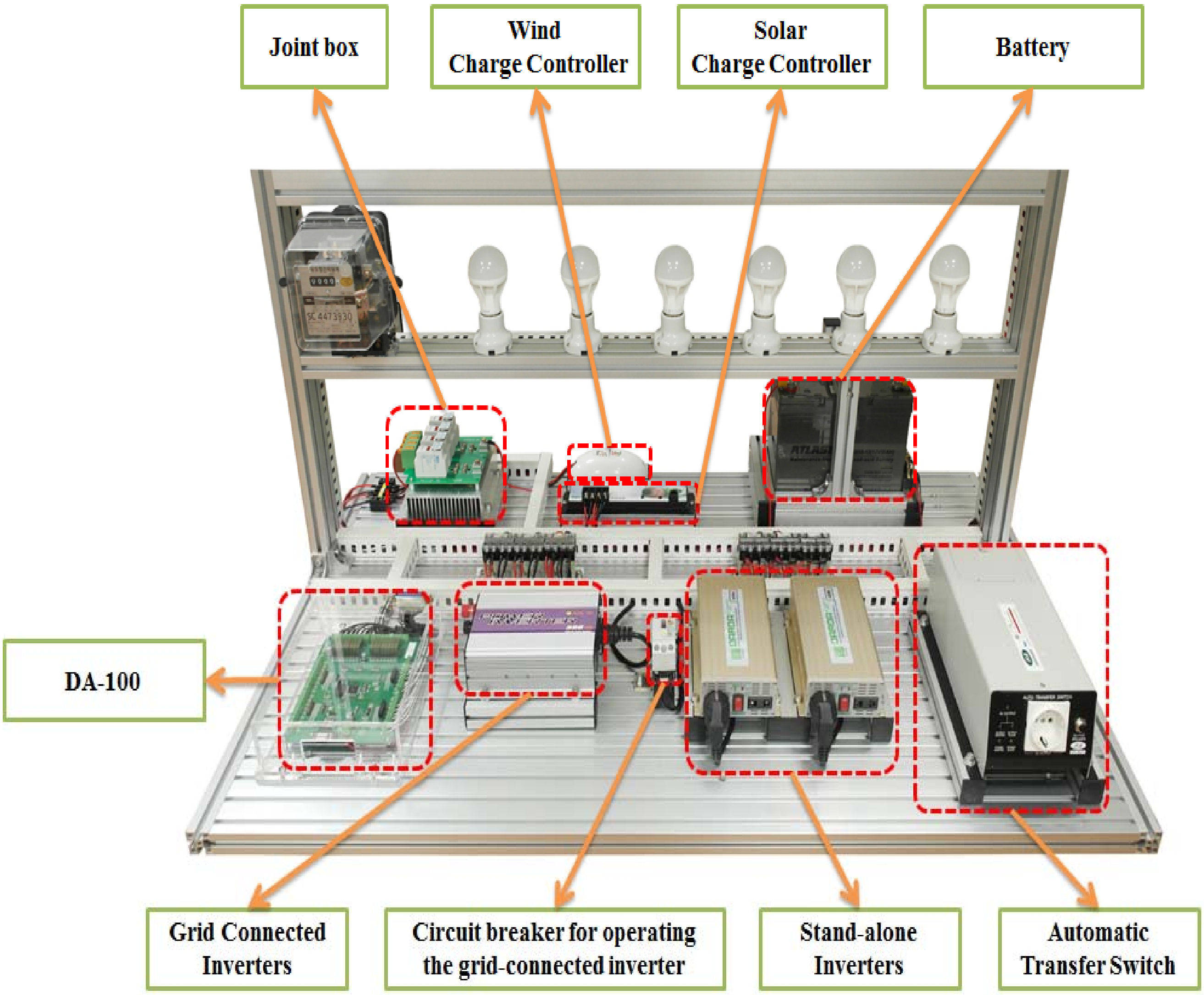


* [+]Terminal 3EA
* [-]Terminal 3EA
* Terminal Lamp 3EA

Diagram 3-15 Load Select Terminal

Once you connect 40W load terminal with each of the output terminal of inverter, import and ATS using banana jacks, and start the system, the connected lamp will start to work. Since the system uses AC, you must connect them in parallel.

3-2. Composition of Generator of Electric Converter



(1) Joint Box

Diagram 3-16 Joint Box

It receives electricity generated from the solar generator (stationary type).

(2) Charge Controller

Diagram 3-17 Charge Controller

It converts the unstable electricity generated from the solar/wind generators to a constant 12V electricity and protects the batterty from over-charging and discharging.

(3) Battery

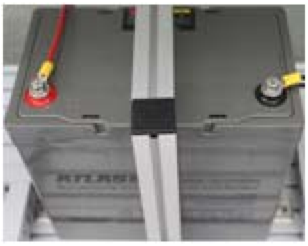


Diagram 3-18 Battery (12V)

It stores electricity generated from the solar generator in a form of 12V DC. If the input voltage is unstable, the life of battery will be shortened and may cause problems when charging, so the charge controller should be used to charge.

(4) Stand-alone inverter

Diagram 3-19 Inverter (500W)

It converts 12V DC to 220V AC. It receives 12V DC from the battery, converts it to AC and supply it to the load.

(5) Grid-Connected Inverter

Diagram 3-20 Grid-Connected Inverter (300W)

It converts 12V DC to 220V AC. It communicates to the commercial electricity system to supply power to the load and supply the left over electricity to the system.

(6) Auto Transfer Switch (ATS)

Diagram 3-21 ATS, Auto Transfer Switch

ATS, Automatic Transfer Switch, secures double or triple power in order to automatically switch to spare electricity when the main power is cut or the voltage thereof falls below the standard rate, allowing the user to be supplied with a constant power.

(7) Load

Diagram 3-22 Lamp (40W, 6EA)

6, 40W incandescent lamps for AC220V are used to use used as loads for load testing with electricity generated.

4. Data Acquisition device between PC and machine

4-1. Install and how to use KTE-DA100

(1) INSTALL USB TO SERIAL

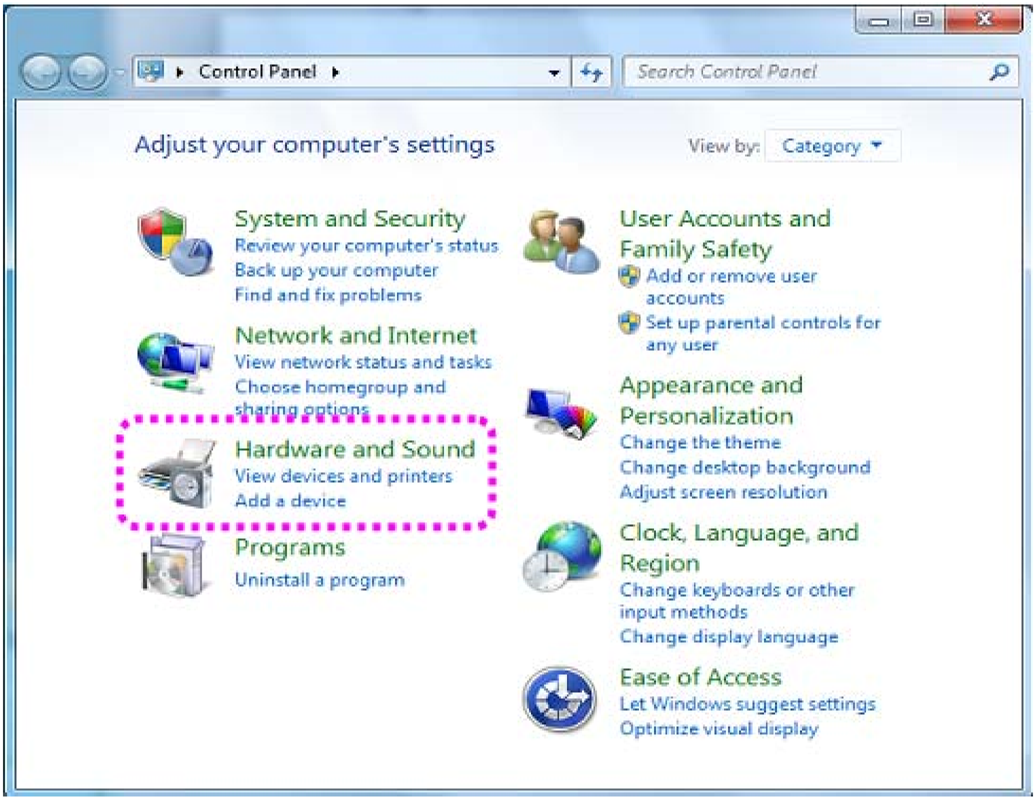
- Communication method is using computer and RS232 protocol for communication.
- If you got a desktop which is connected with Serial Port back. you don't have to install USB To Serial.
- If you got a desktop which doesn't have notebook or Serial Port, you need to install progress for collecting data using USB Port.

1) Run Windows 7

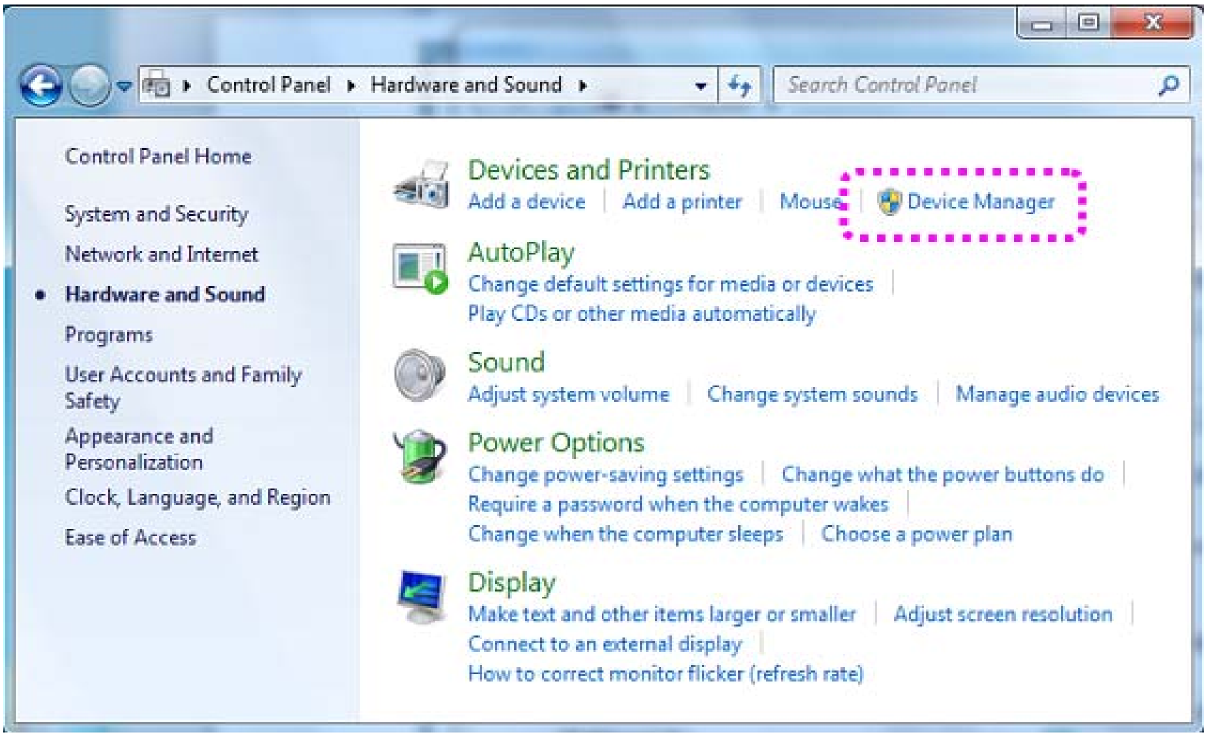
2) Connect USB MultiPort to your PC’s USB port.

3) Inset media CD(provided with MultiPort) into the CD drive.

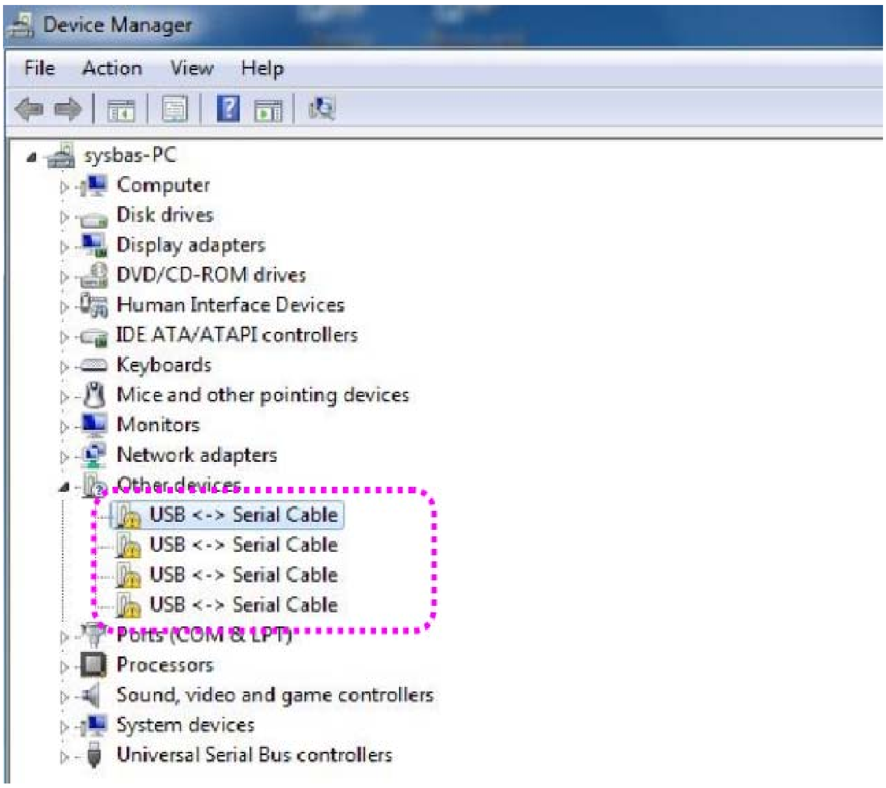
4) Click “Hardware and Sound” in “Control Panel”



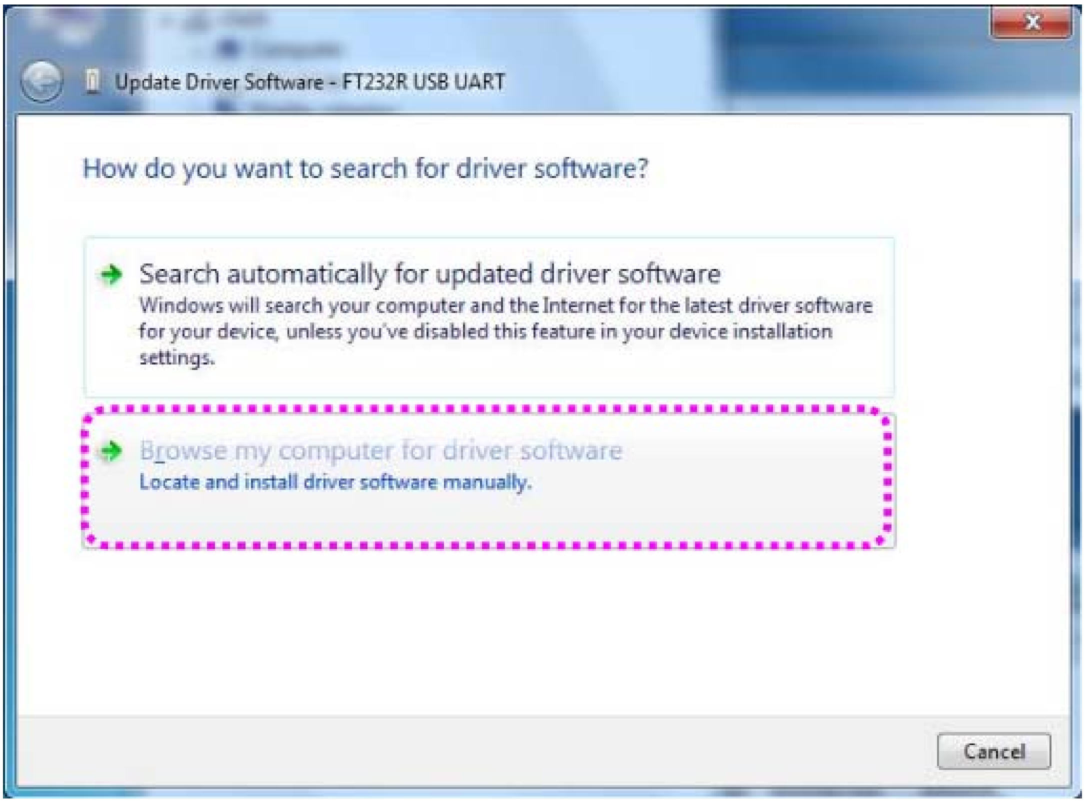
5) Following picture depicts Device Manager after carrying out step 4. Click “Device Manager”.



6) Right click “USB <-> Serial Cable” in “Device Manager”. Then choose “Update Driver Software”.

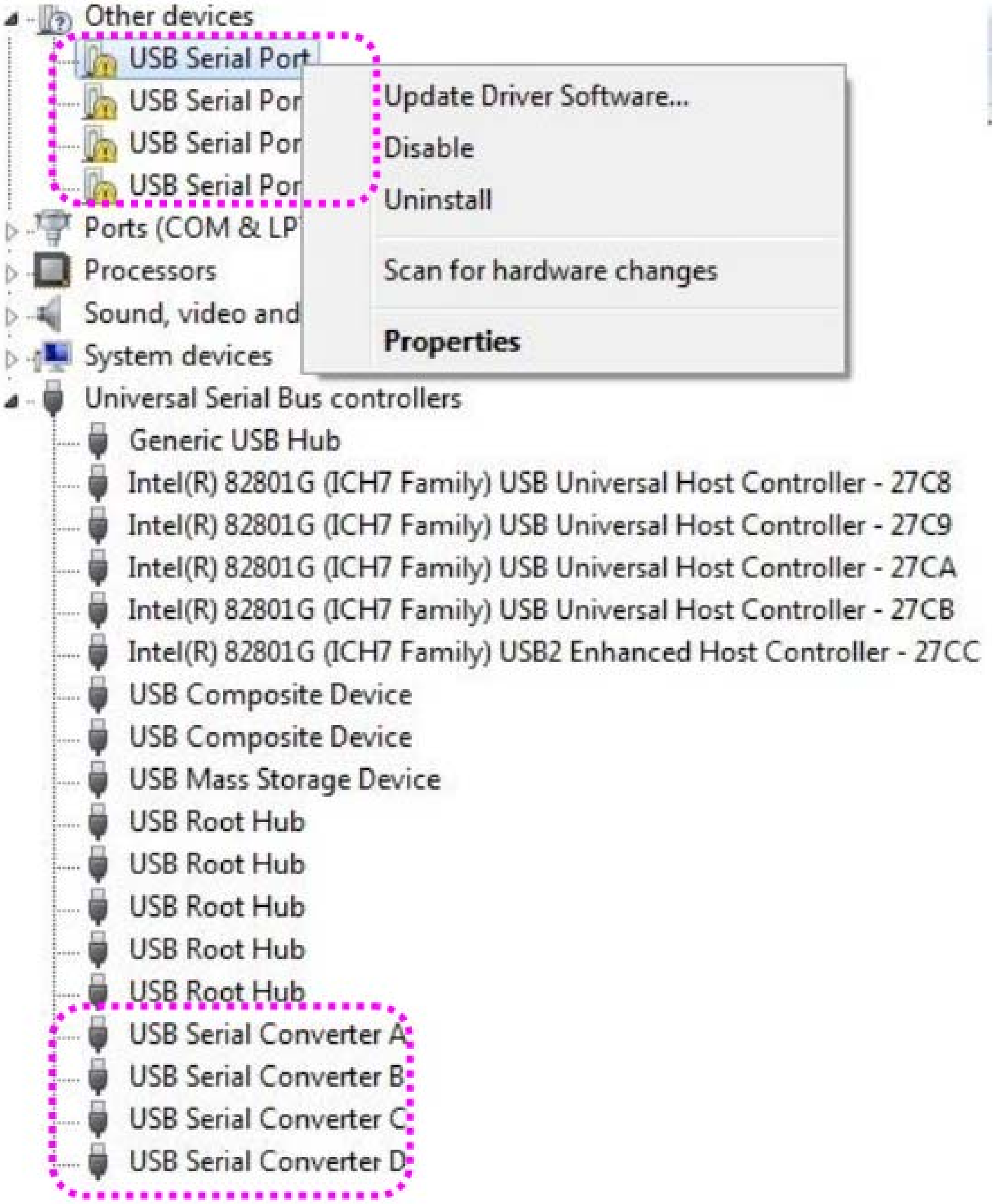


7) Click "Browse my computer for driver software"in order to install driver manually.

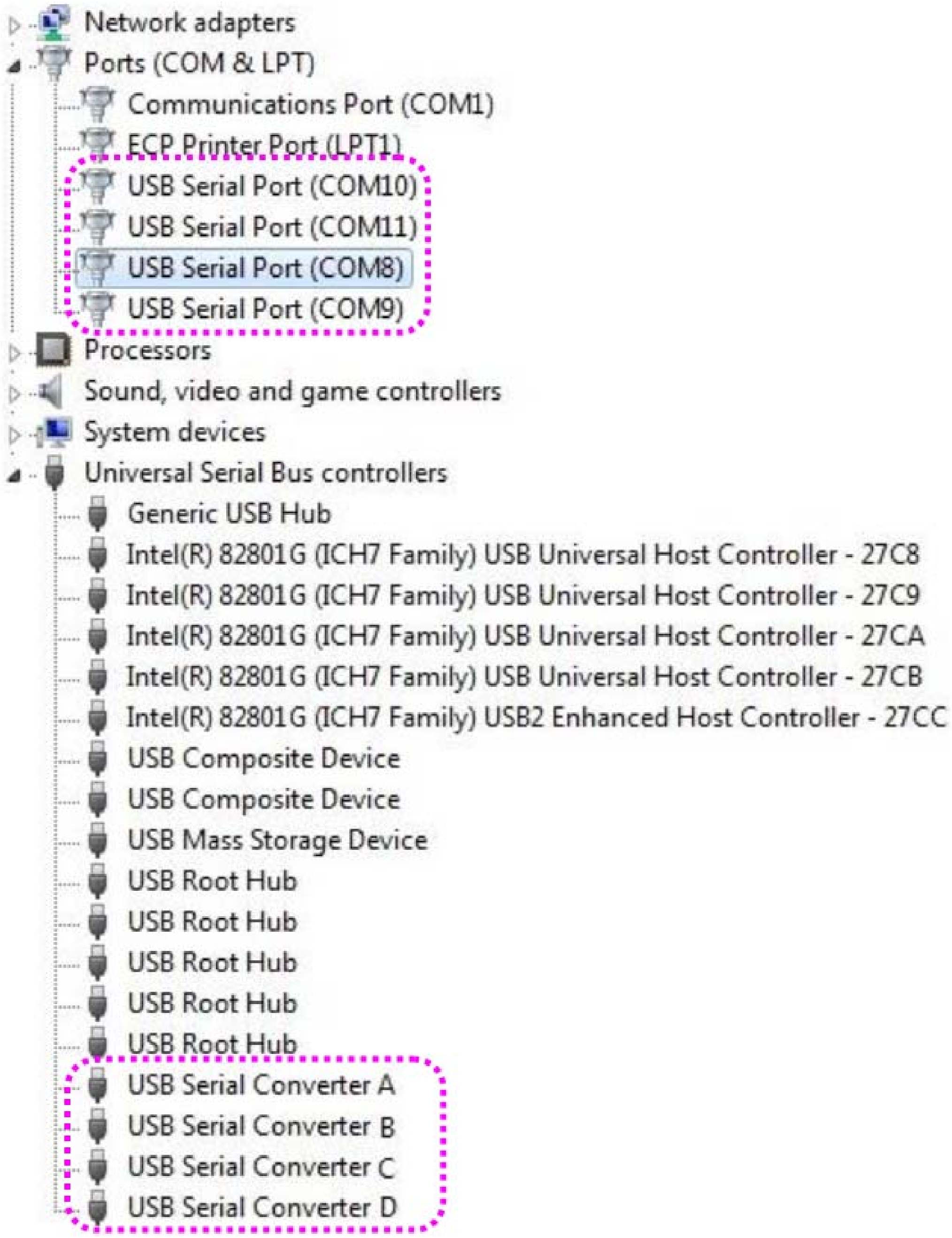


8) Click "Browse"and set driver software's location to [CD]:\Driver\USB\Win2000\,XP,2003,Vista,2008,7".

9) Confirm that “USB Serial Converter” is installed normally. Then, right click “USB Serial Port”and follow the same process from number 6 again.



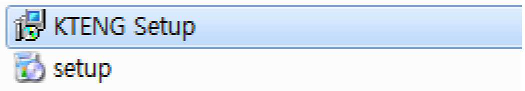
10) Following picture depicts "Device Manager"after carrying out all steps. As can be seen, all "USB Serial Converters" and"USB Serial Ports" are successfully installed.



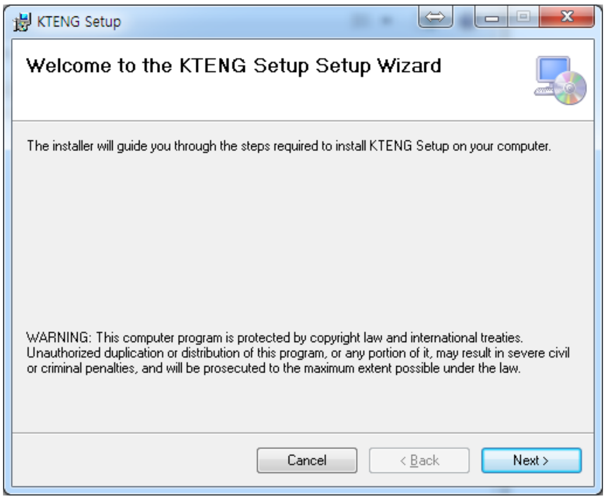
11) "USB Multiport"installation on Window 7 is now finished.

(2) KTE-DA100 Installation and Operating

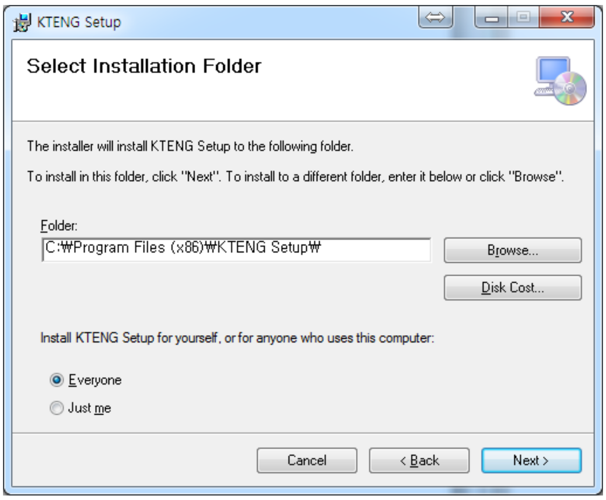
① KTE-DA100 Installation



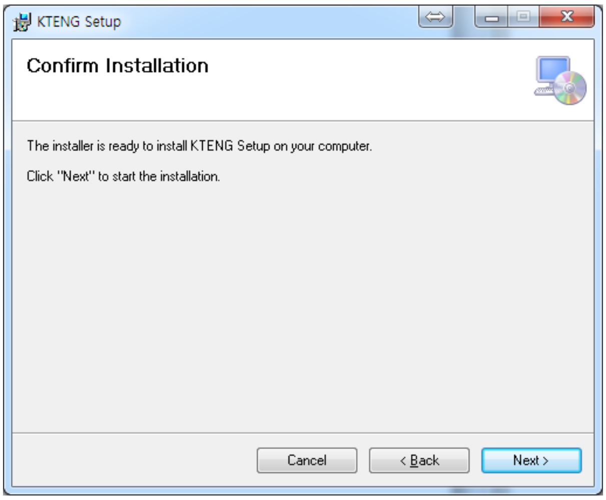
1) You can see a installation files that in CD or USB for installation then double click ‘KTENG Setup’ file to start installation. If the program cannot be installed using ‘KTENG Setup’, try to ‘setup’file.



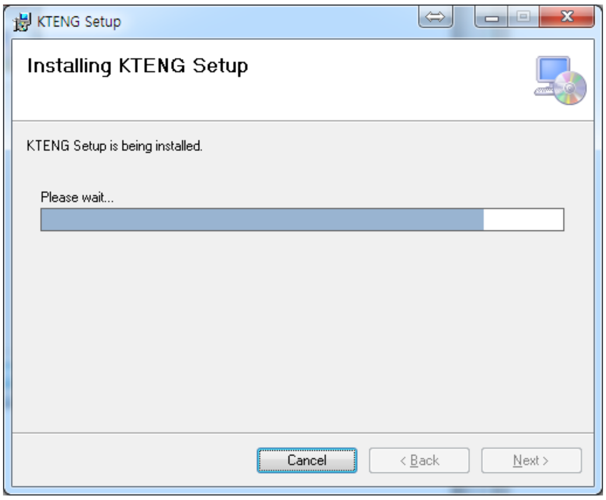
2) If you can see a ‘Setup Wizard’ screen, click the ‘Next>’.



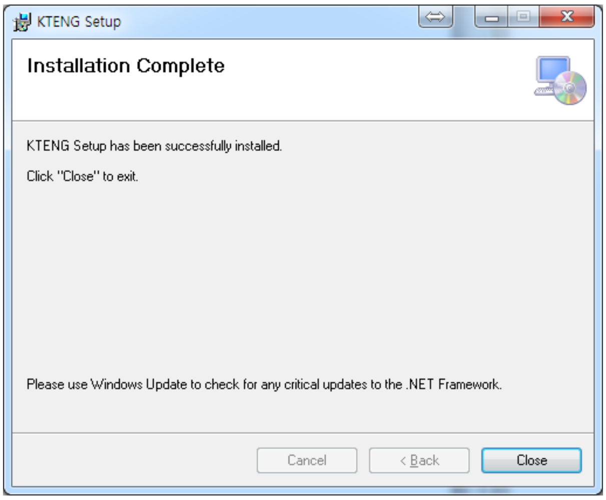
3) You can change a installation route. If you want to change a installation route, click the ‘Browse..’ and find a new route then click the ‘Next>’.



4) It require to confirm installation intention. Please click the‘Next>’.

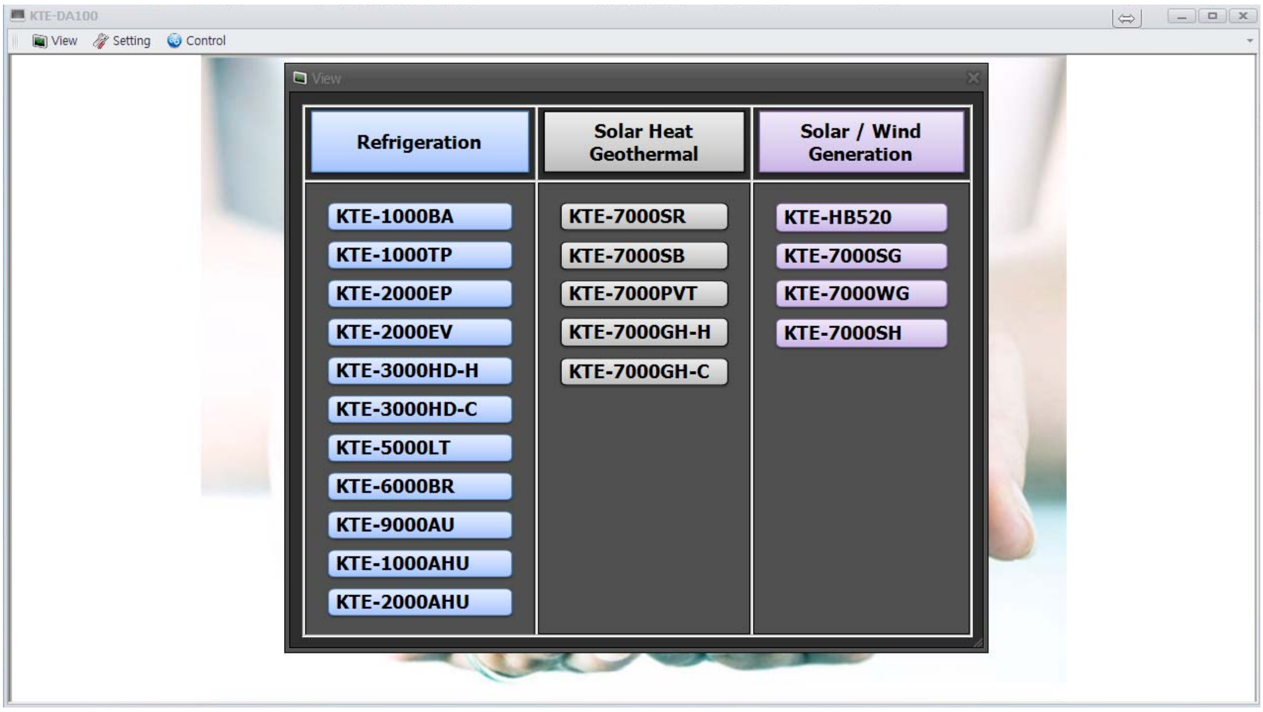


5) Installing a program.



6) Please click the ‘Close’ and complete a installation.

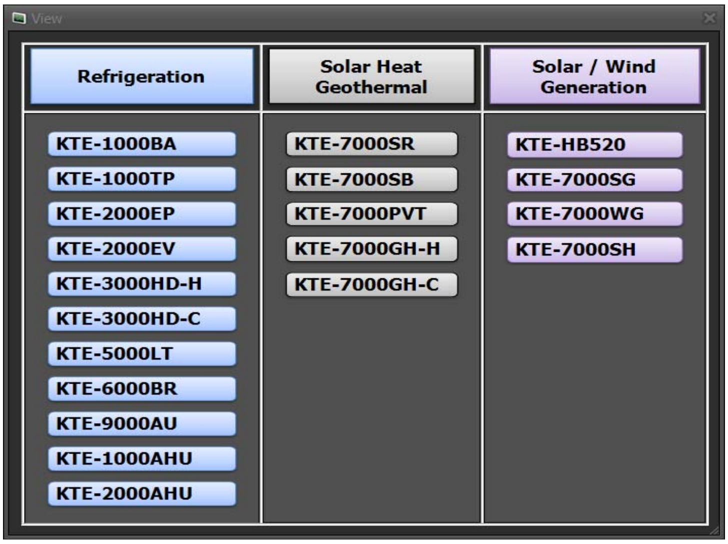
7) Start program by using icon in wallpaper or routing folder then the main page of program come up.



KTE-1000BA	Standard Refrigeration Experimental Equipment	KTE-7000SR	Solar Radiation Energy Experimental Equipment
KTE-2000EP	Evaporation Pressure Parallel Control Experimental Equipment	KTE-7000SB	Solar Heating Hot Water Boiler Experimental Equipment
KTE-2000EV	Refrigerant Parallel Expansion Valve Experimental Equipment	KTE-7000PVT	PVT Performance Measuring Equipment
KTE-3000HD-H	4-Way Reverse Valve Control Heat Pump Experimental Equipment (Heating Mode)	KTE-7000GH-H	Geothermal Heat Pump Experimenatl Equipment (Heating Mode)
KTE-3000HD-C	4-Way Reverse Valve Control Heat Pump Experimental Equipment (Cooling Mode)	KTE-7000GH-C	Geothermal Heat Pump Experimenatl Equipment (Cooling Mode)
KTE-5000LT	Binary Refrigeration Experimental Equipment	KTE-HB520N	Hybrid Power Conversion Experimental Equipment
KTE-6000BR	Brine Refrigeration Experimental Equipment	KTE-7000SG	Solar Power Generation Experimental Equipment
KTE-9000AU	Car Air-Conditioner Experimental Equipment	KTE-7000WG	Wind Power Generation Experimental Equipment
KTE-1000AHU	Air-Conditioning Unit Automatic Control Equipment	KTE-7000SH	Solar-hydrogen Fuel Cell Experimental Equipment
KTE-2000AHU	Air Handing Unit Lab-view Programing Equipment		

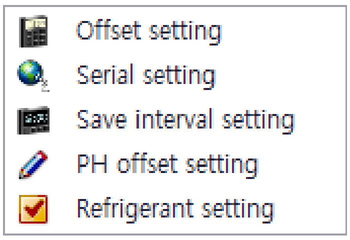
② Main Menu Composition

1) View

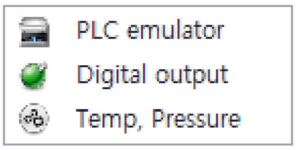


(Refrigeration 11 species, Solar-Geothermal 5 species, Solar-Wind energy 4 species)

2) Setting



3) Control



(3) Setting

Menu	Explain
Offset Setting	Setting initial pressure, temperature
Serial Setting	Communicating port setting
Save Interval Setting	Setting data acquisition time interval
PH Offset Setting	Setting range of axis at p-h chart
Refrigerant Setting	Select refrigerants

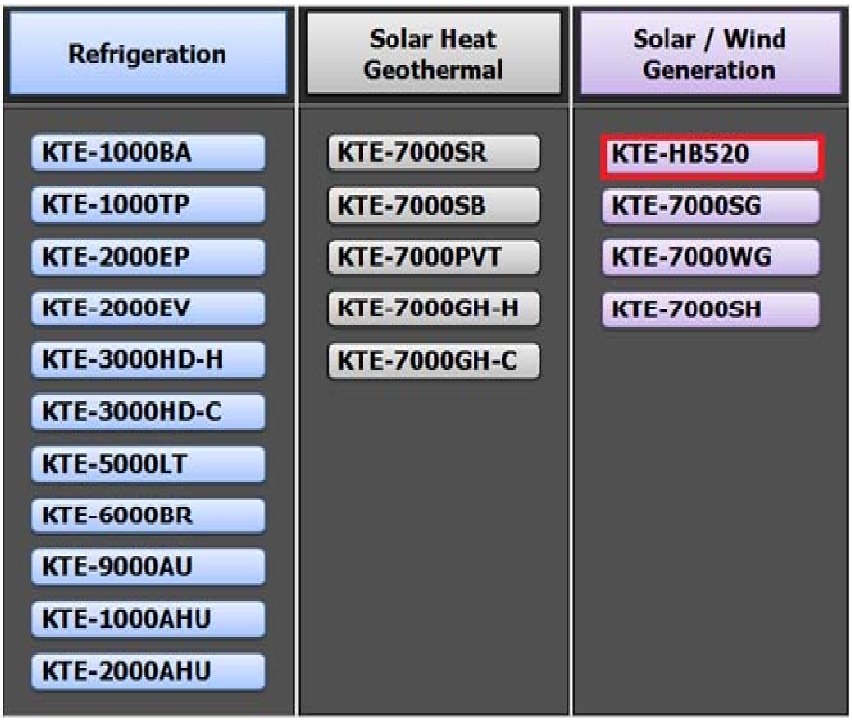
※ Please refer to page 69 for more detail information.

(4) Control

Menu	Explain
PLC emulator	Using PLC control
Digital output	Control a Hardware
Temp, pressure	Control a temperature, pressure

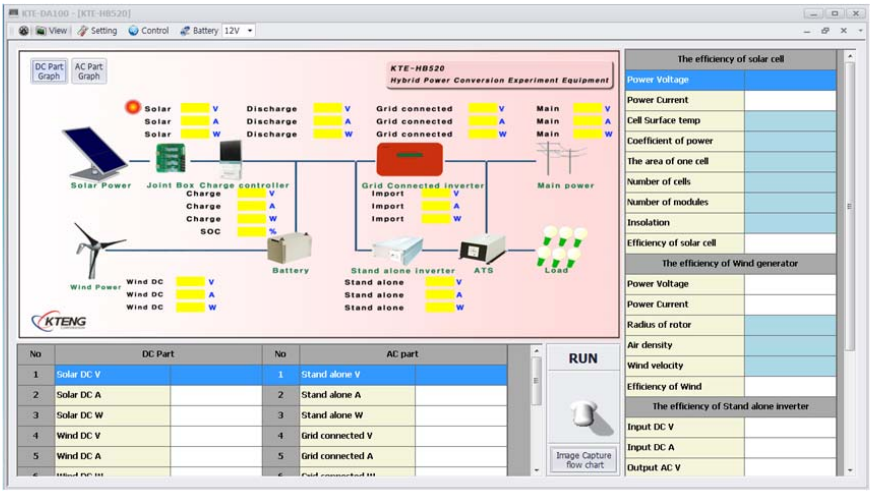
(5) Application of data acquisition equipment(Model : KTE-DA100)

① Selection of Model



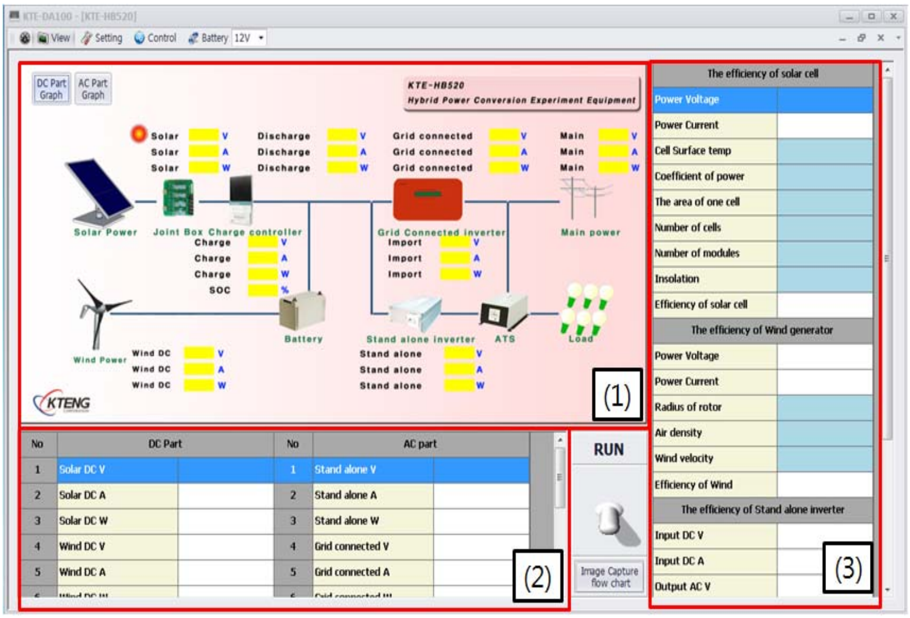
(1) When program started, 'View'screen is activated.

(2) Select a model what you want. (Click the KTE-HB520N)



(3) Main user interface of KTE-HB520N is activated.

i) Composition of main user interface

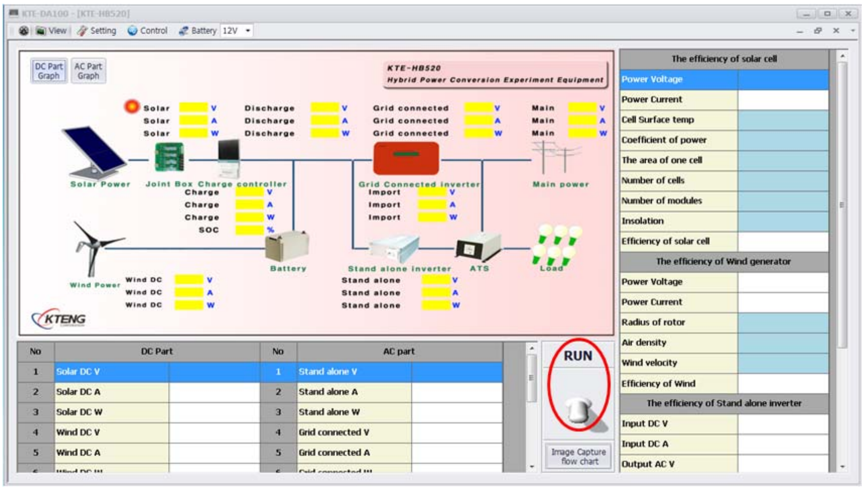


(1) Diagram display area and real-time voltage and current configuration

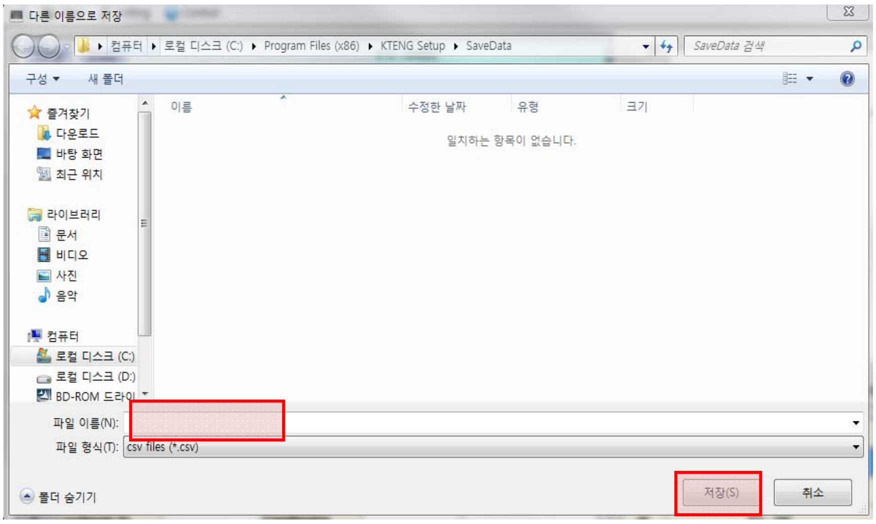
(2) Voltage, current, power chart.

(3) Solar cell efficiency, Wind turbine efficiency, Stand-alone and grid–connectedinverterinverterefficiency calculations

ii) Operating and saving data



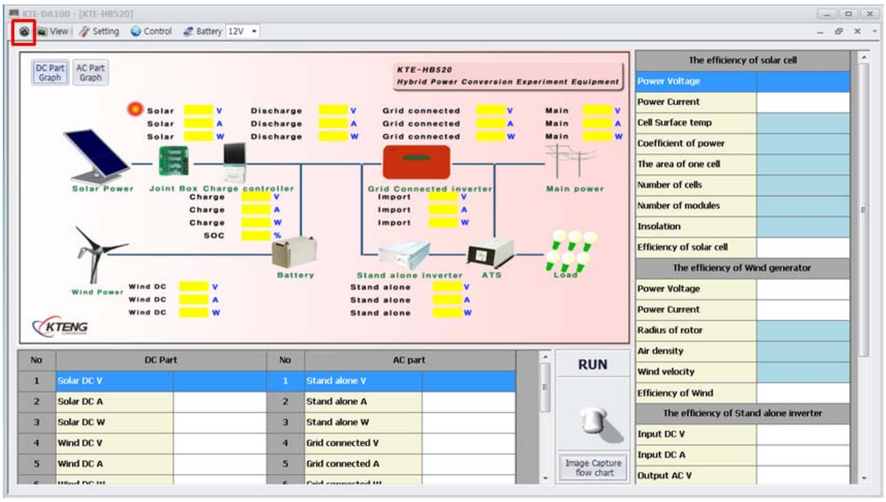
(1) Click a toggle switch to run program to save data.

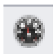


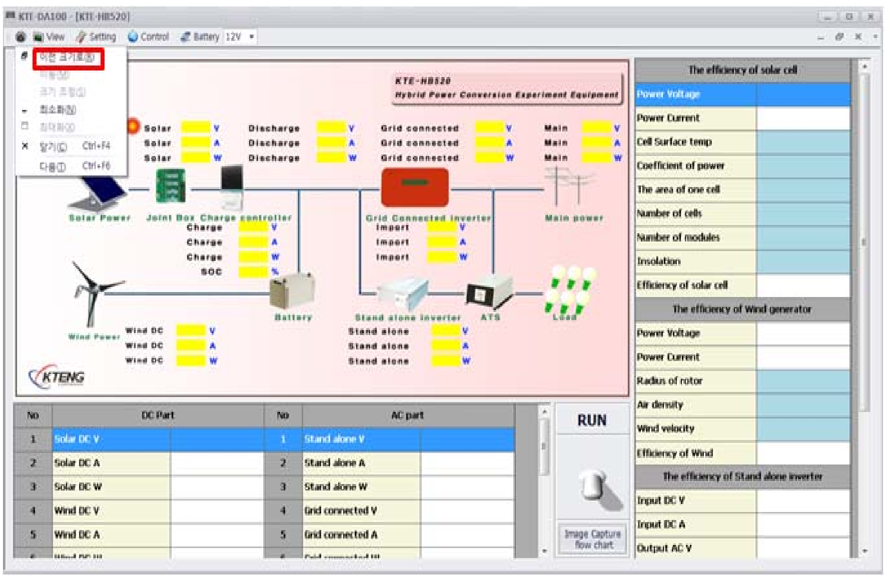
(2) Write a title and save a file by excel.

② Function for collecting data tools

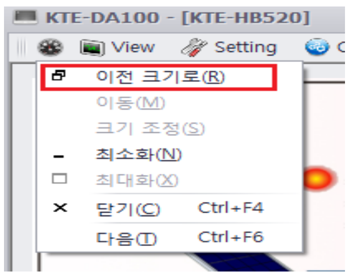
ⅰ)Tools

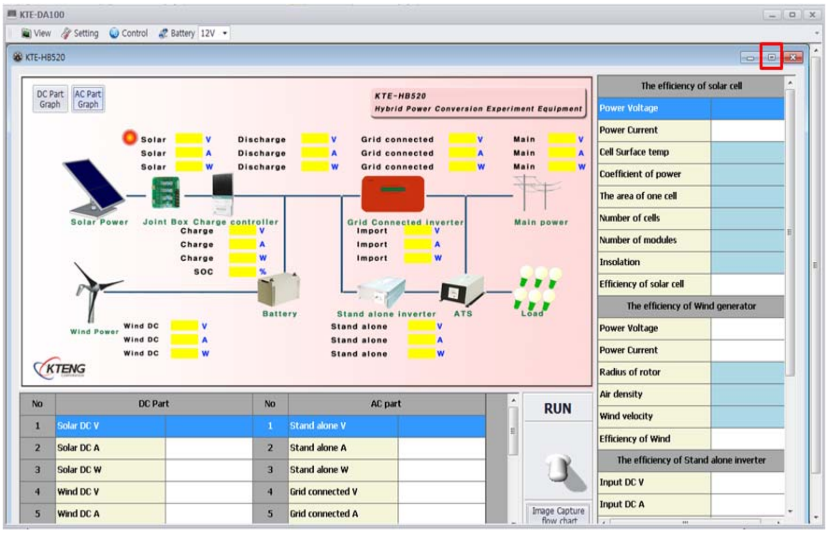


(1) Click  in Tools

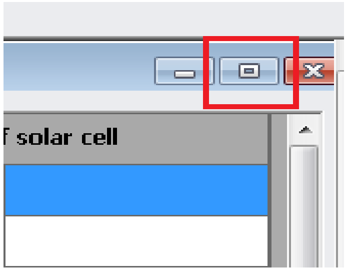


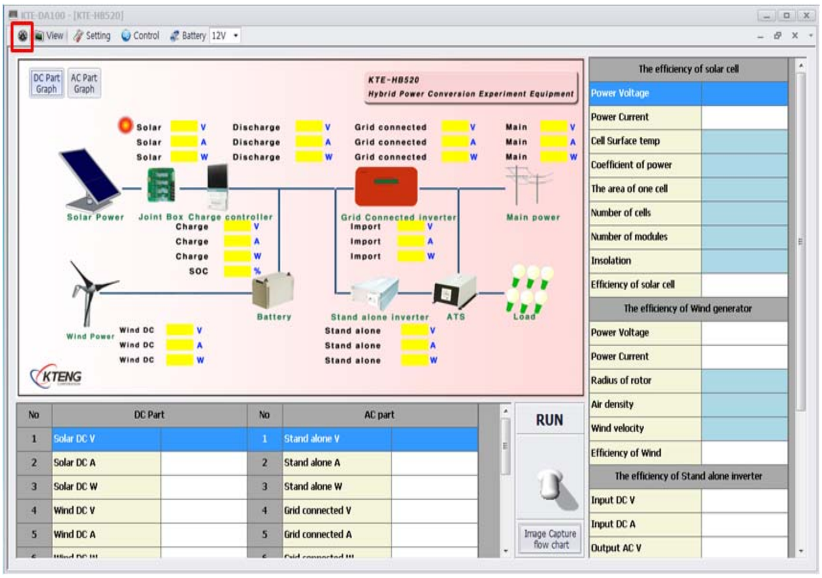
(2) When you click (R) for before size, the window is activated for moving



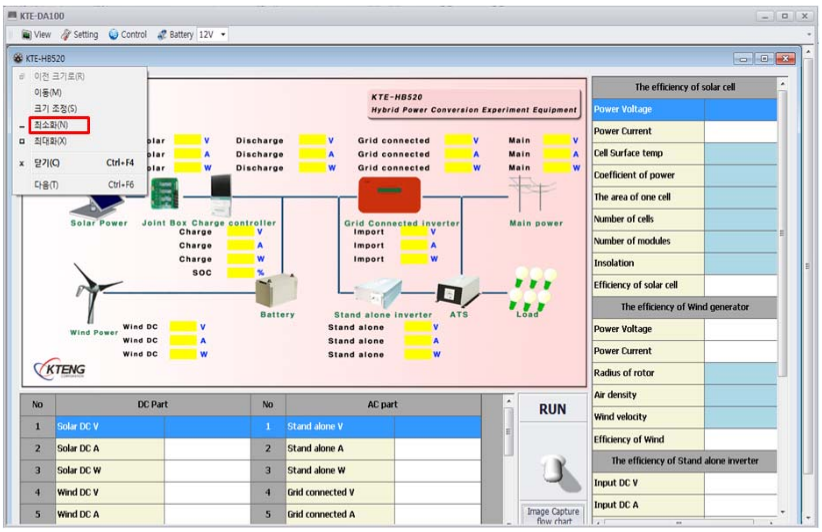


(3) Click that button, the window is bigger.

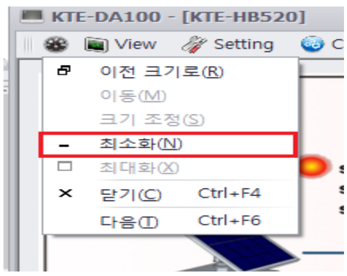




(4)  Click



(5) When click the minimum(N), indicate bottom of the left side.

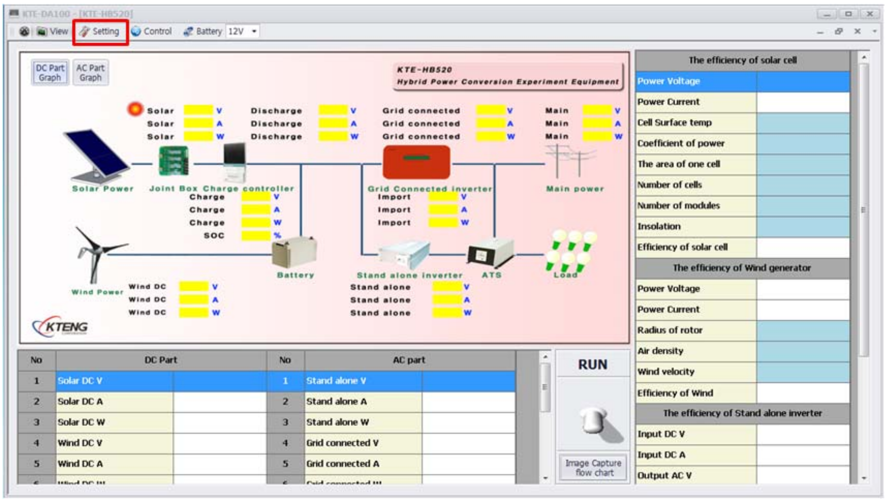


(6) When click whole monitor, it is returned.

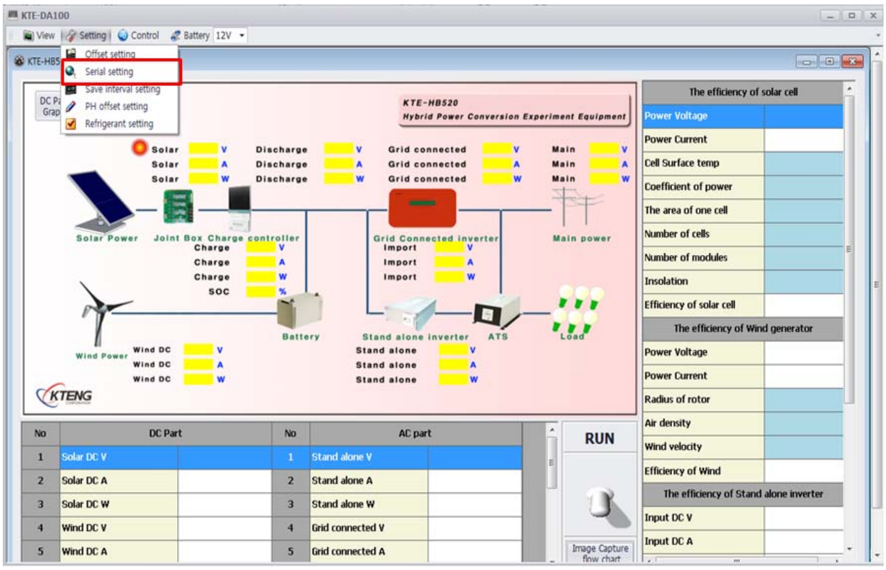
iii) Setting

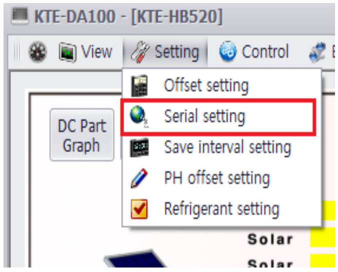
① Serial setting

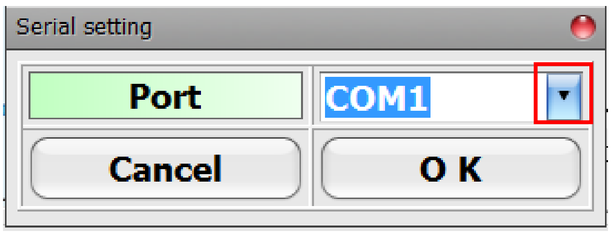
(1) Click Setting



(2) Click Serial setting



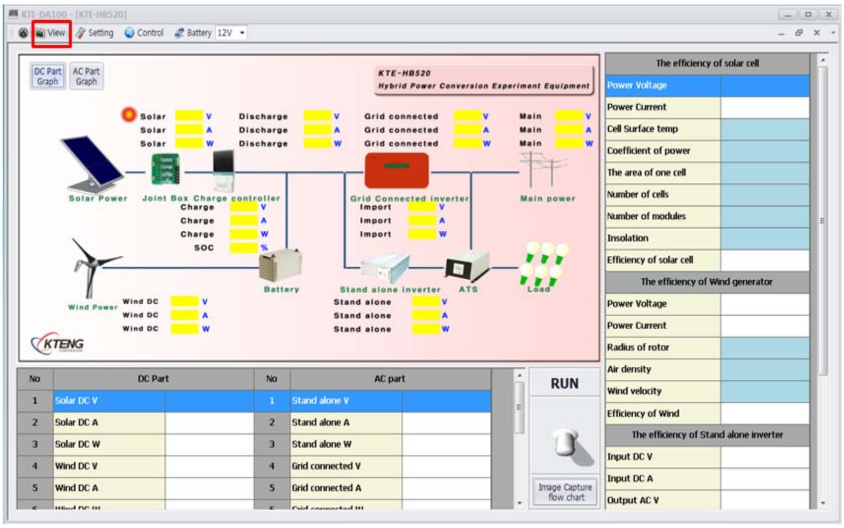




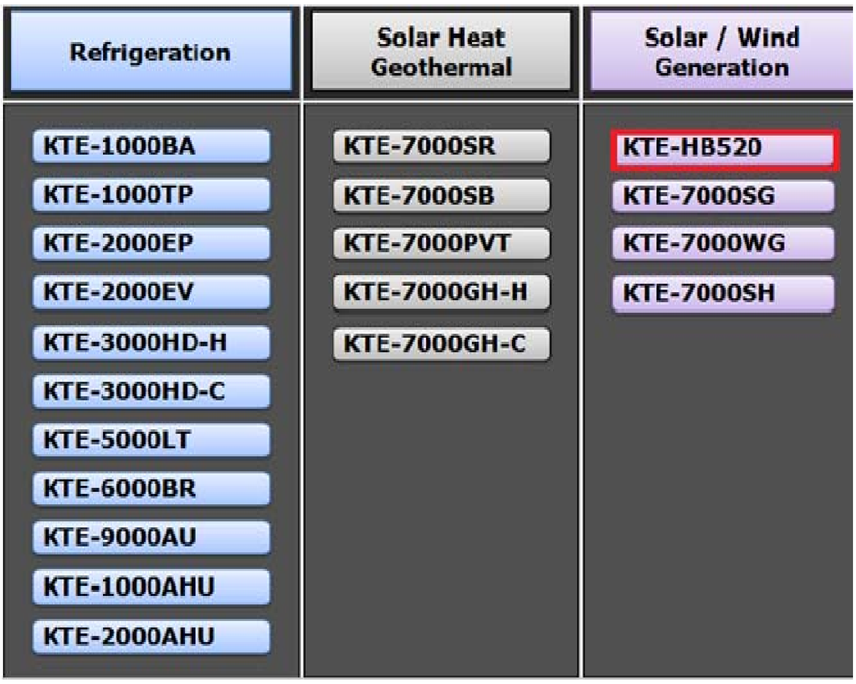
(3)
COM No is changed depend on port location. choose COM No and Click OK

※Chcking port No is on Page_1-1 use to serial installation

ii) View

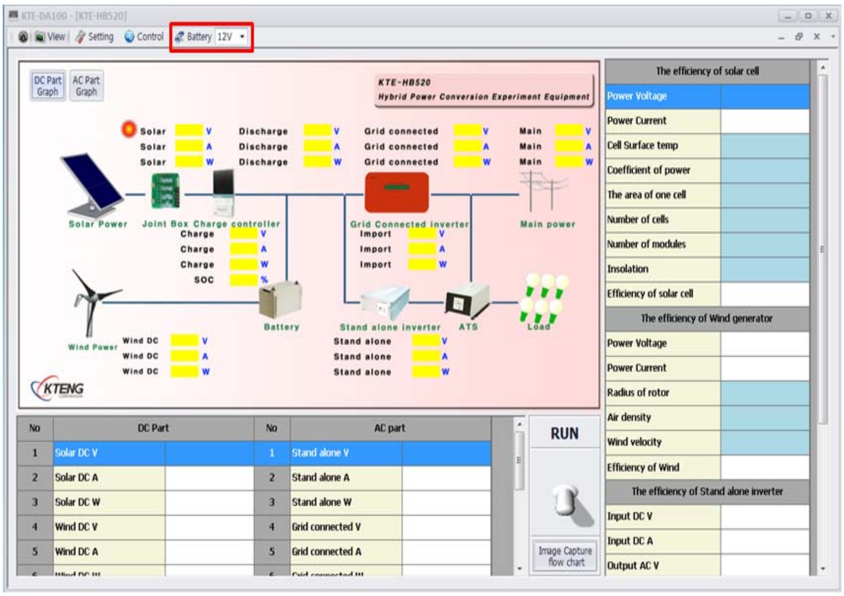


(1) Click the view in Tools

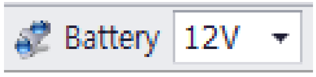


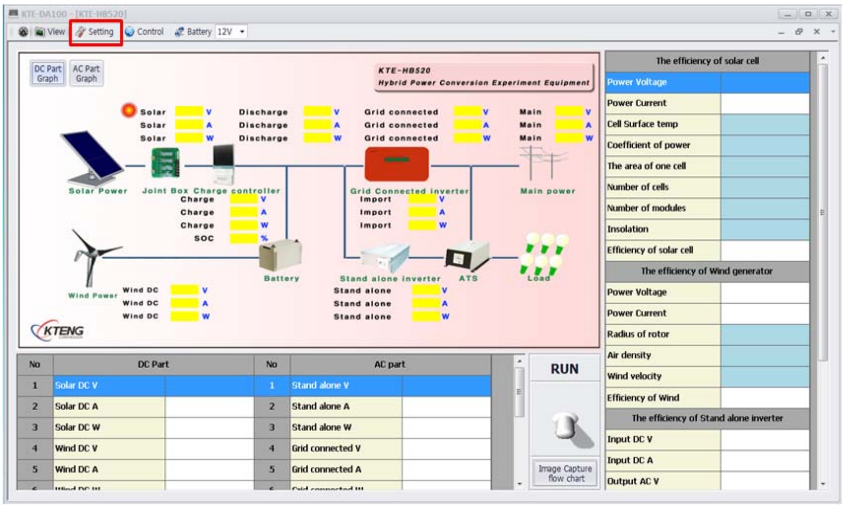
(2) When you click the view and click Model name then it goes to main screen and it indicates program screen which is connected with real equipments

② Offset setting

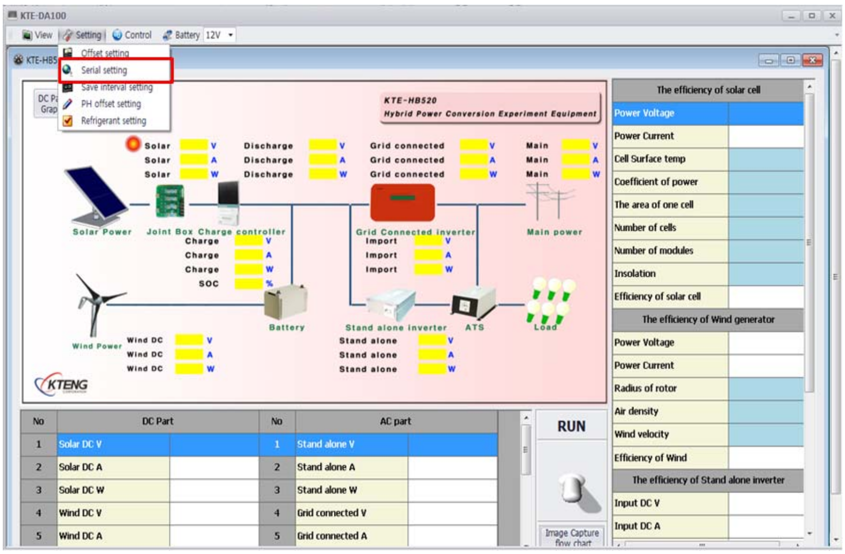


(1) Click 12V Setting in Tools(Battery)

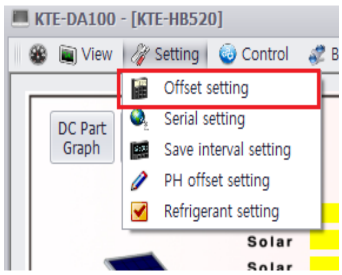


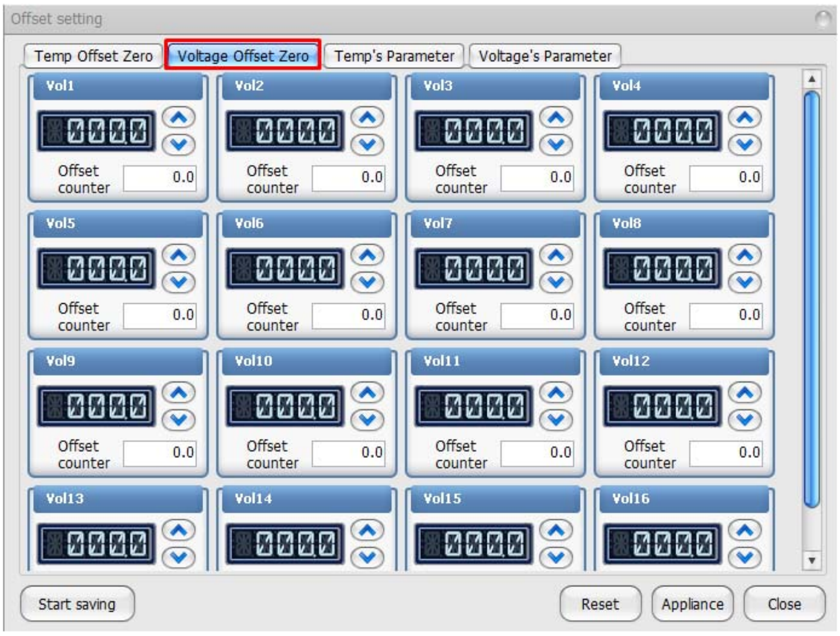


(2) Click Setting in Tools



(3) Click Offset Setting



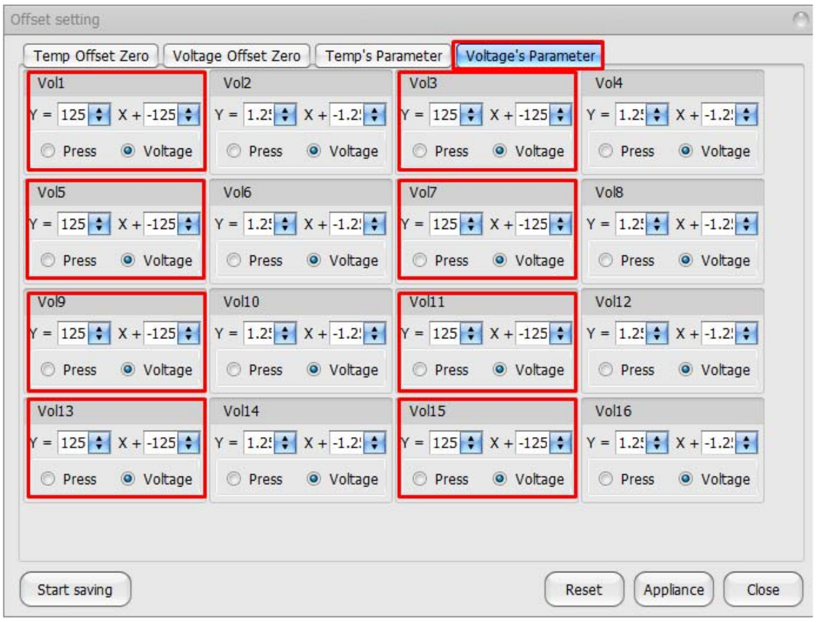


(4) Voltage Offset Zero is a part of can control voltage

 : You can control using direction key

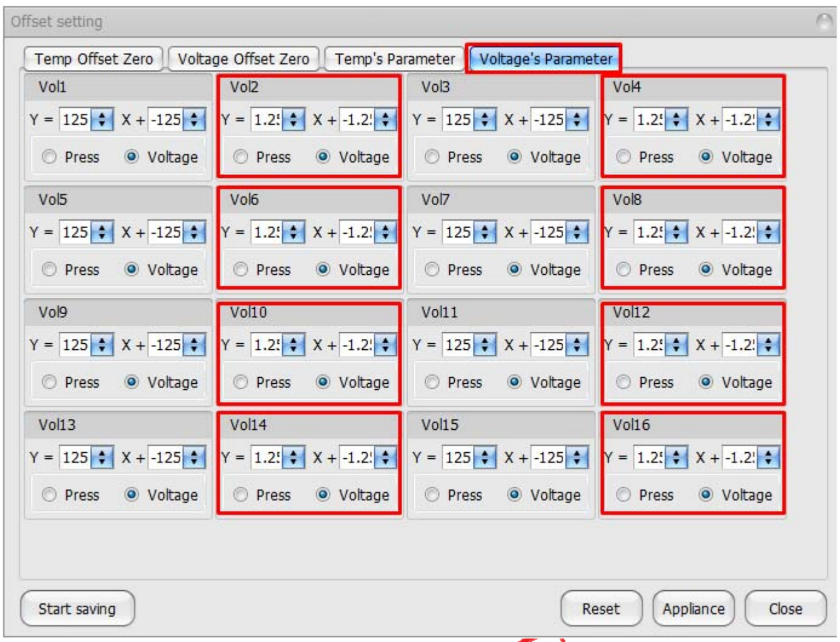
 : It is indication for voltage figure

Click the application then click the Close for applying the figure

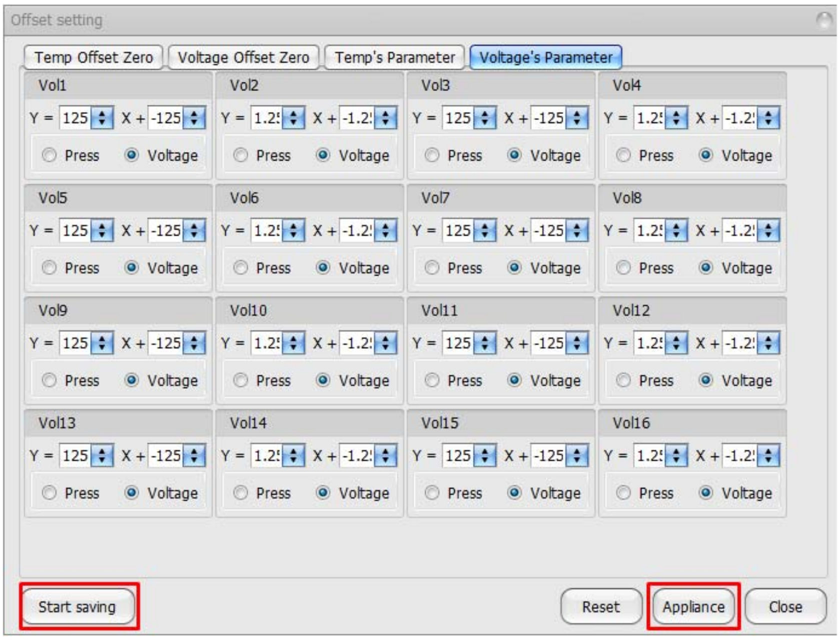


(5) Voltage`s Parameter has a function which can input the figure for changing input figure, You can set as choosing Voltage.

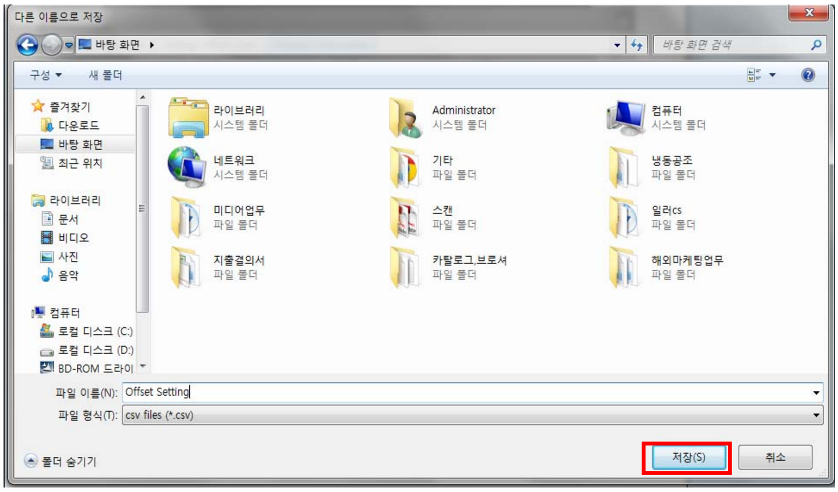
Vol1, Vol3, Vol5, Vol7, Vol9, Vol11, Vol13, Vol15 must enter a value of “Y=125x-125”



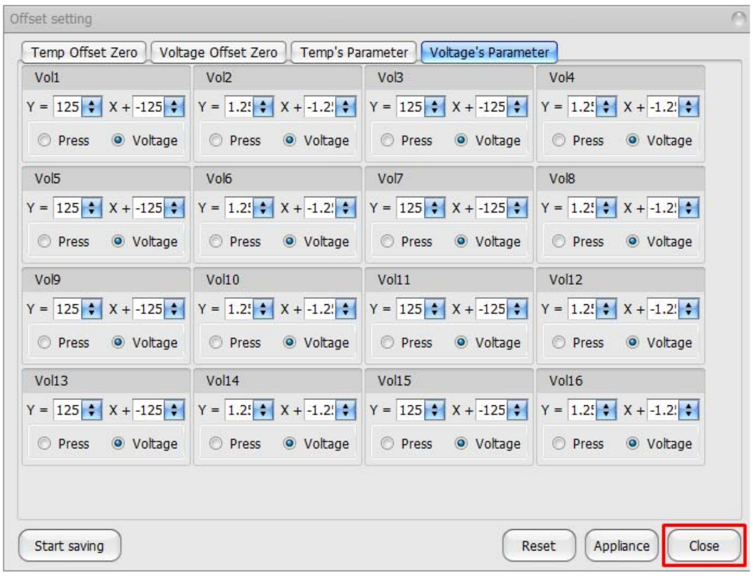
(6) Vol2, Vol4, Vol6, Vol8, Vol10, Vol12, Vol14, Vol16 must enter a value of “Y=1.25x-1.25”



(7) Click“Appliance" and click "Start Saving" for Application.

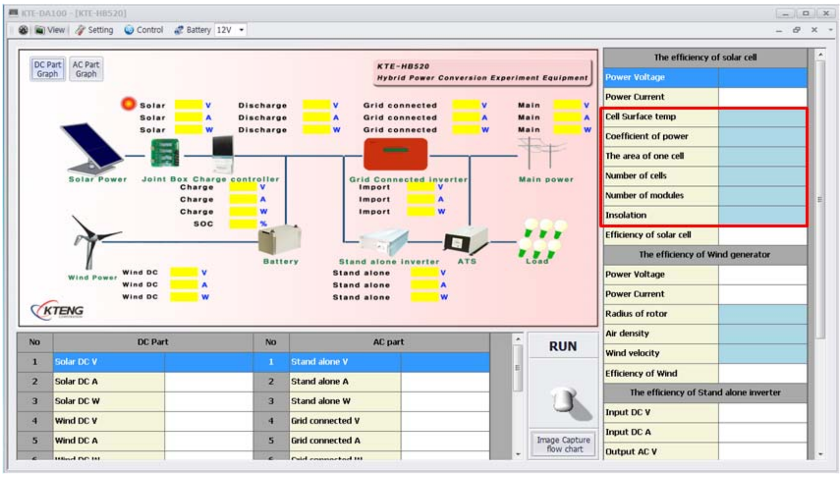


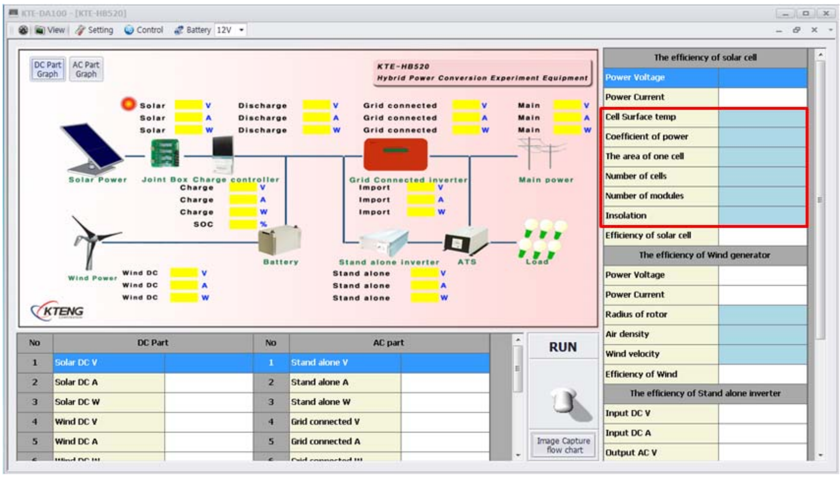
(8) Click Start Saving Save the file name entered in the left side of the screen



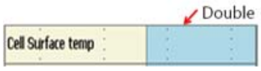
(9) Start saving set figure and Click "Close" on the left screen

④ Efficiency of solar cell setting





(1) enter of measured temperature(ex:60℃)

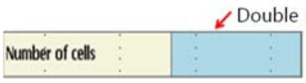


(2) enter a value of “0.4℃”

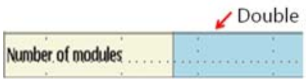
- The temperature coefficientis different according to the type of PV module.
- Crystalline silicon module is "-0.45%"

(3) enter a value of “0.1㎡”

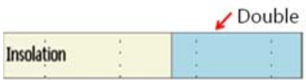
(4) enter a value of “1EA”



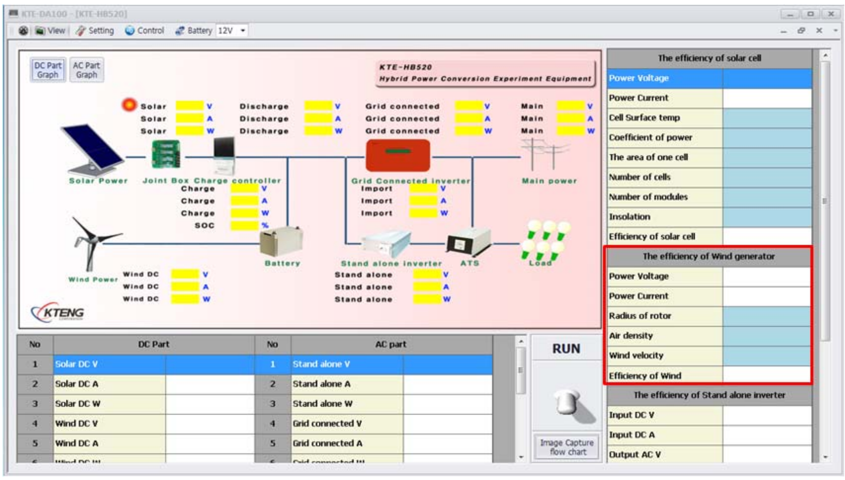
(5) enter a value of “4EA”



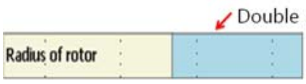
(6) enter a value of “1000W/㎡”



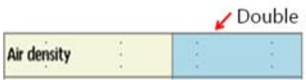
⑤ Efficiency of Wind generator setting



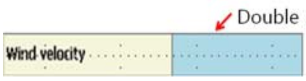
(1) enter a value of “0.2m”



(2) enter a value of “1.3kg/㎥”



(3) enter of measured Wind velocity(ex:6m/s)

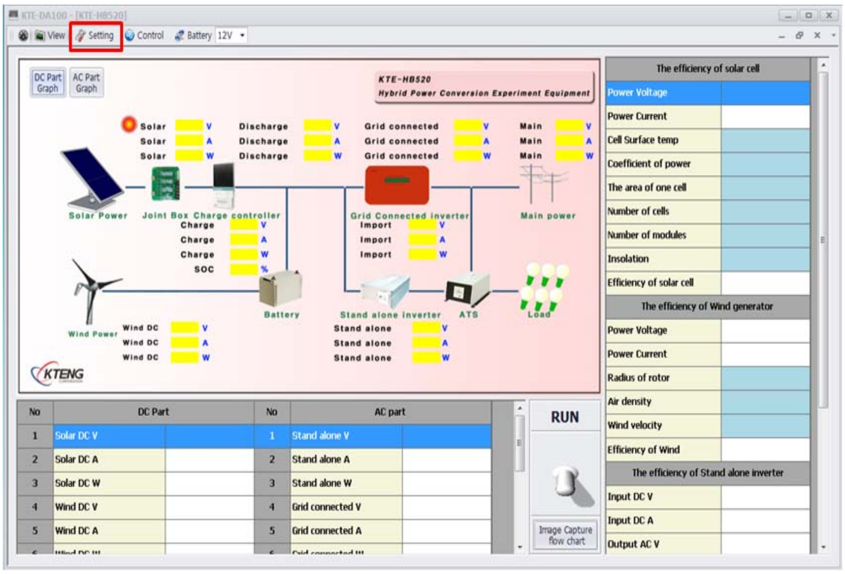


⑥ Calculation

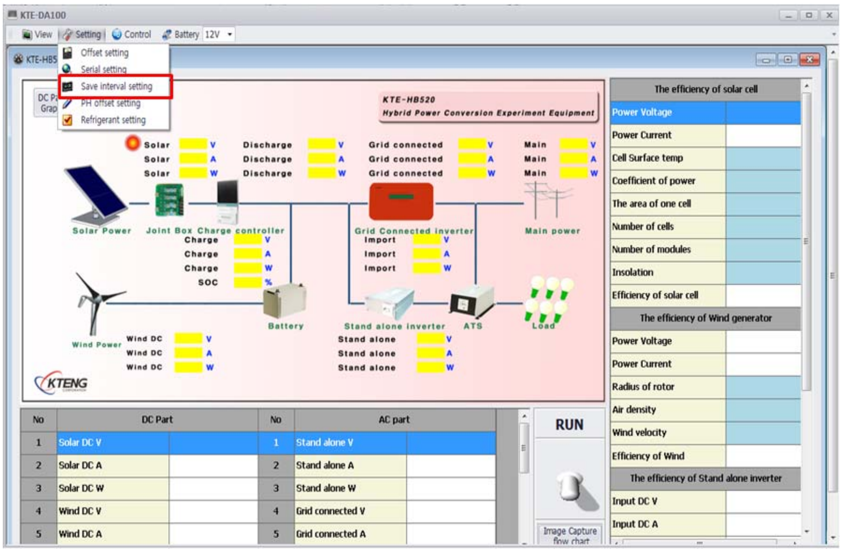
$$\text{Efficiency of Solar Cell} = \frac{(\text{Output Modules "V" x "I"}) + [(\text{Surface Temperature} - 25) \times \text{Output Temperature Coefficient}]}{\text{The area of One Cell(m)} \times \text{Number of Cells(ea)} \times \text{Number of Modules(ea)} \times \text{Insolation}} \times 100\%$$

$$\text{Efficiency of Wind Generator} = 2 \times \frac{(\text{Output Wind Power "V" x "I"})}{(\pi \times \text{Radius of Rotor}^2) \times \text{Wind Velocity}^3 \times \text{Air Density}} \times 100\%$$

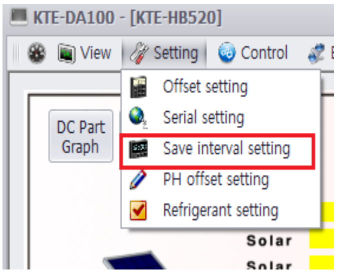
⑦ Save Interval setting

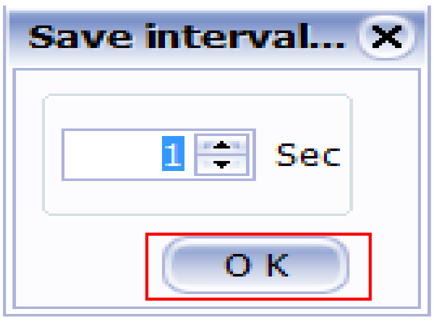


(1)Click Setting



(2) Click Save interval setting

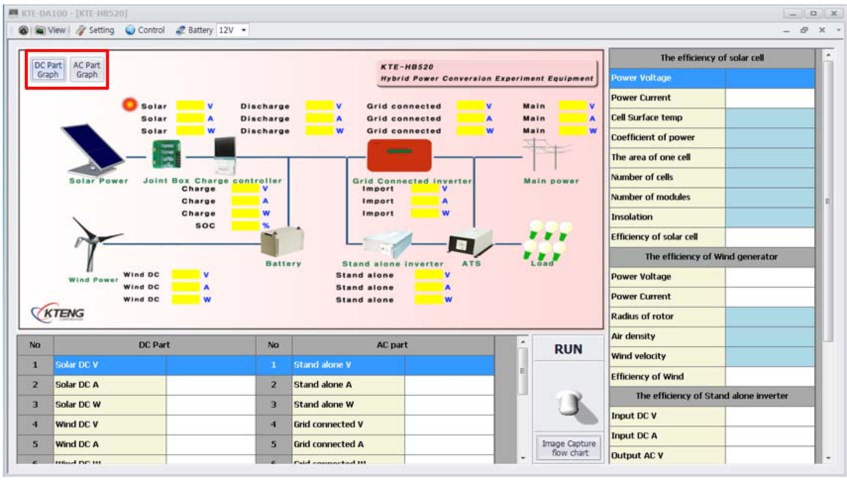




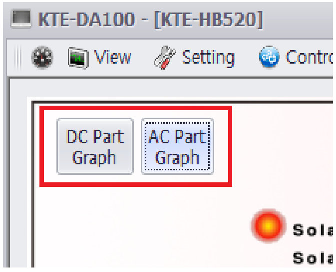
(3) Save interval setting

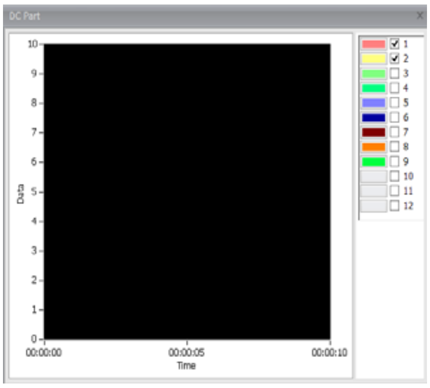
A function for setting a data storage time interval The time interval as an Excel file Can be stored in line.(However, the number of seconds (Sec) because When set to one minute is Set to 60Sec)

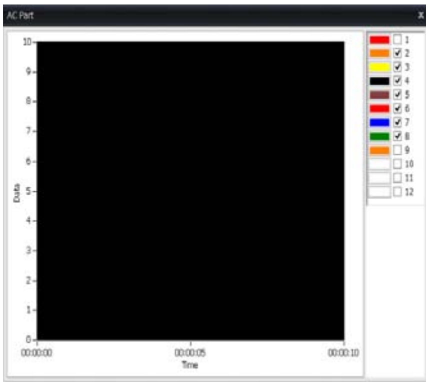
(6) Other Functions



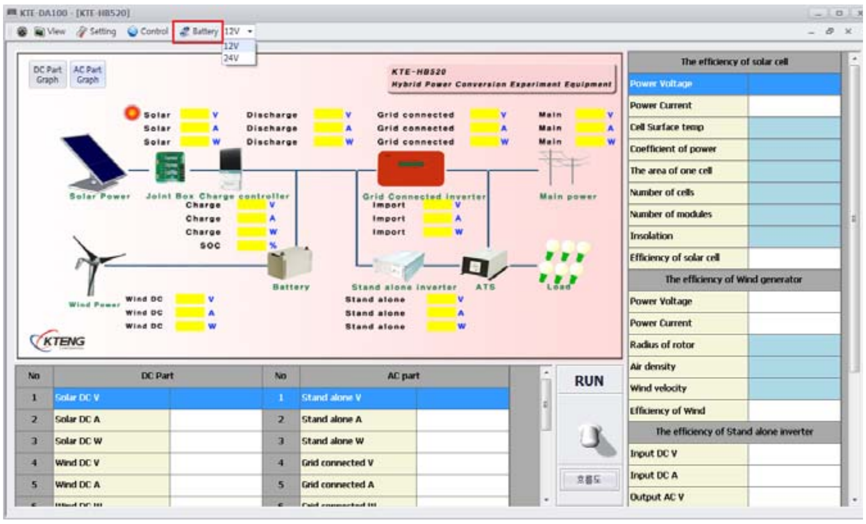
(1) Dc Part, Ac Part Graph DiagramView
Click on the top left of the icon



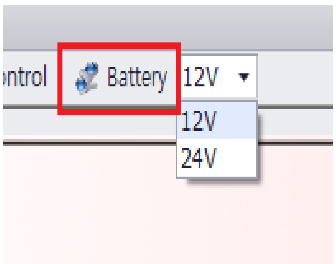




(2) When selected, can be viewed in real-time to fit the screen by selecting the number



(3) can be selected to 12V, 24V the voltage of the battery

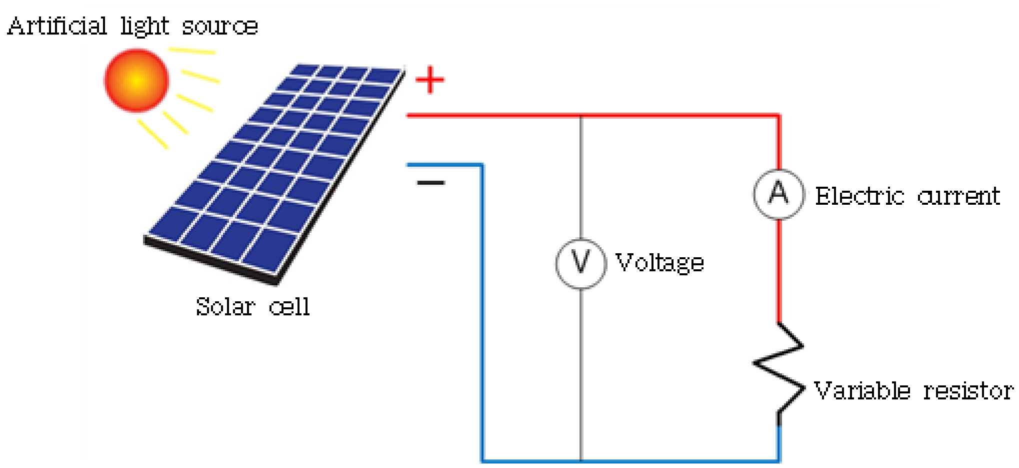


5. Operating circuit construction and commissioning of equipment

Experiment name	1. Experiment with the output voltage and current measurements of solar modules and calculate the efficiency of modules according to their load resistance changes	**Class time(hr)** 8
Object	① Measuring the output voltage and current of a solar module ② Describing the output characeristics of the solar module according to the load change ③ Calculating the efficiency of a solar module	

Experiment equipment	**Tool & material**	**Spec of tools**	**Q`nty**
· Hybrid Power Conversion Experiment Equipment (KTE-HB520N)	· Driver · Nipper · Wire stripper · Hook meter	· #2× 6× 175㎜ · 150㎜ · 0.5~6㎟ · 300A 600V	1 1 1 1/Group

Control Circuit



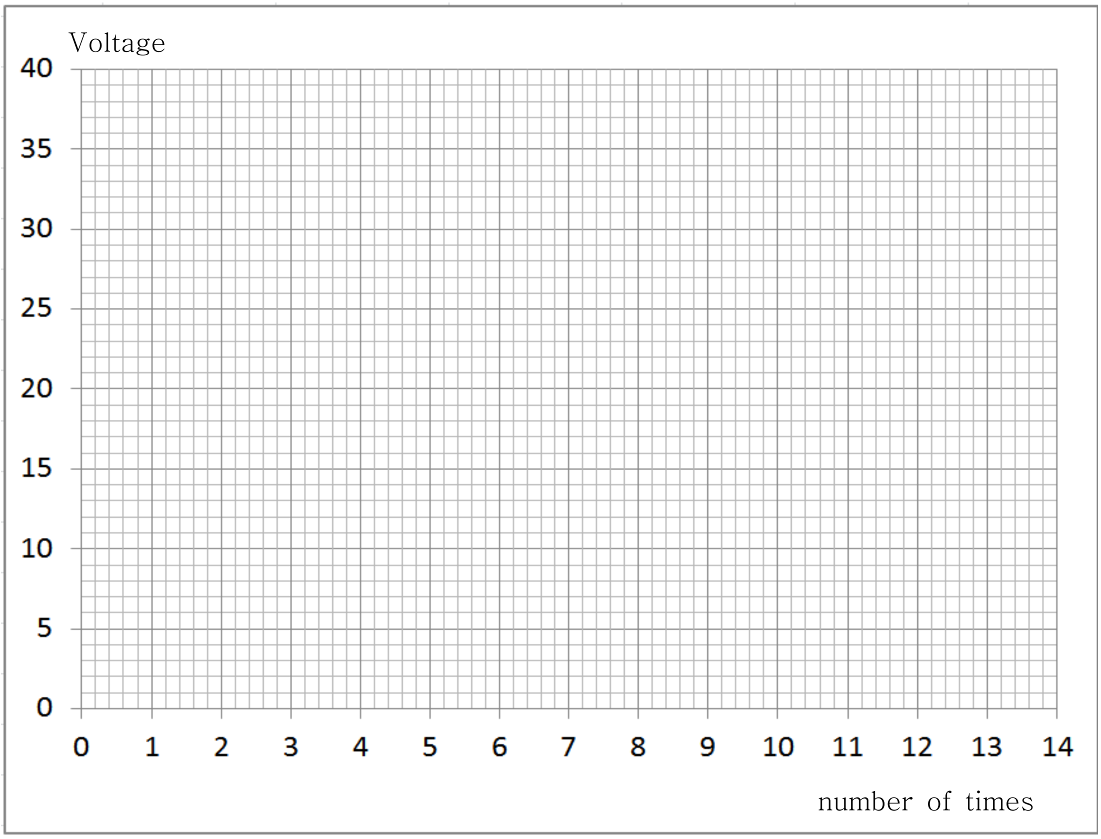
1) Circuit configuration
   (1) The circuit diagrams are connected with the wiring diagram above.
   (2) The load department can regulate consumption power through resistance control.
2) Experimental method
   (1) Power up the artificial light source and illuminate the solar module horizontally with the artificial light source at regular intervals.
   (2) Switch on the artificial light source.
   (3) Gradually change the resistance from load 0 through the variation of resistance to measure the changed voltage and current and calculate the power.

3. Measurement experiment

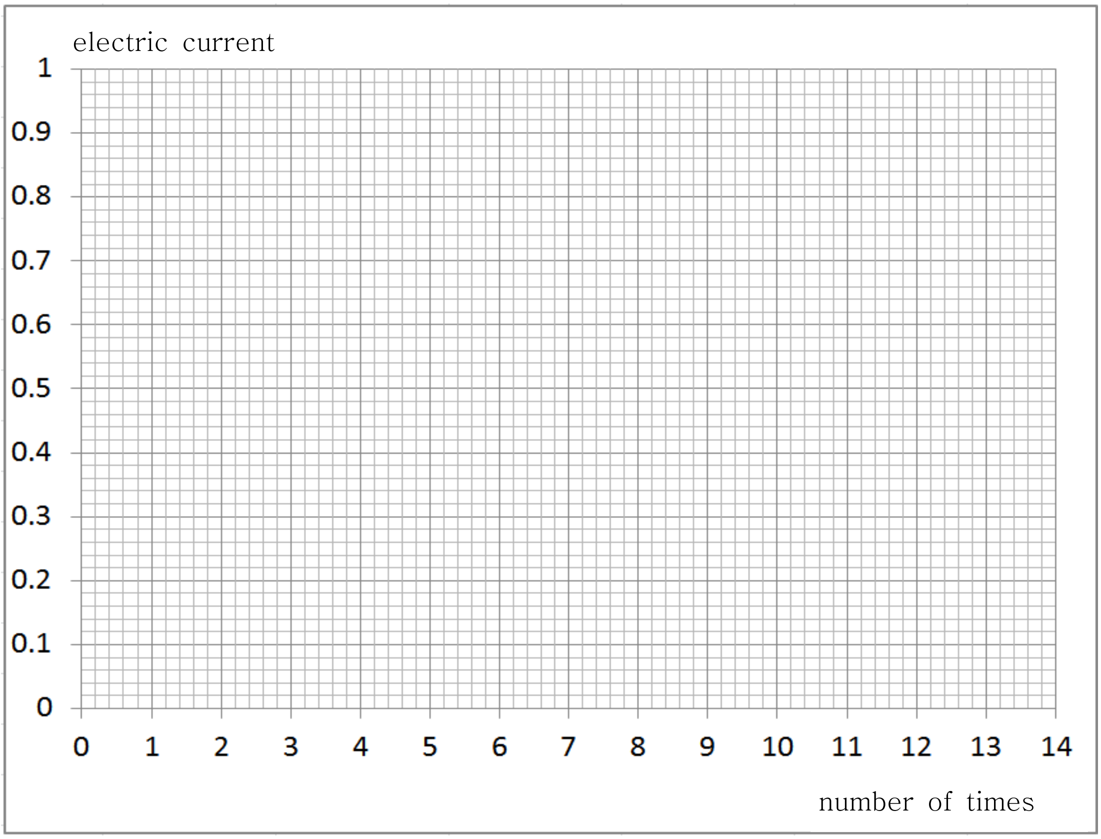
(1) Measure voltage V, current I (A) values below and Calculate the power and resistance values in the table

number	1	2	3	4	5	6	7	8	9	10	11	12	13	14
V														
I(A)														
R(Ω)														
P(W)														

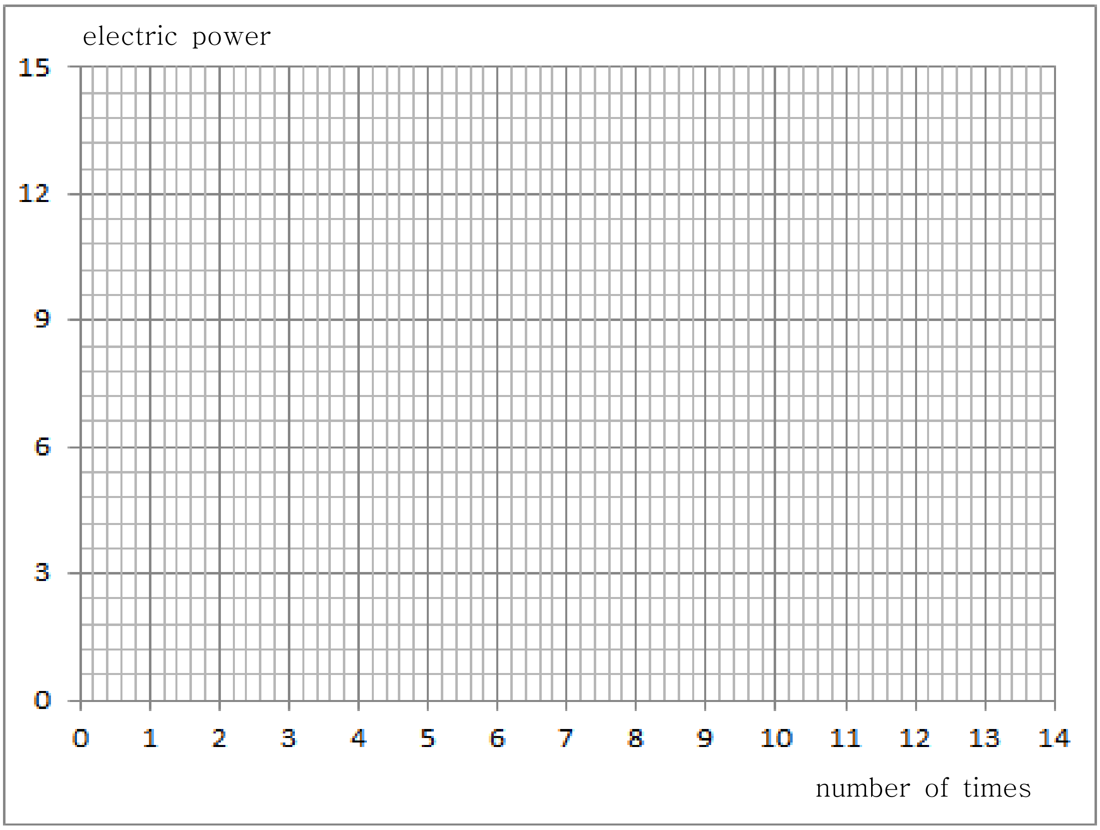
(2) Draw a voltage (V) curve.



(3) Draw current (I) curve.



(4) Draw a curve of power (W).



(5) Measure the W/m^2 values per cell

- Since the method of power conversion per unit of measured value is the reference value of measurement using a pyranometer, the measured value is the horizontal * vertical (1m *1m), and the measured value is the same as the measured value below.

1) Measured value of pyranometer:1m*1m = Converted value : Actual horizontal length * Actual vertical length
2) When all of the values converted into each cell are combined, it is possible to calculate the energy employed in a module using the artificial sun.
3) Convert the energy employed in a module to power(P_{input})

eq. P_{input} = Converted value(W/m^2) * horizontal cell length * vertical cell length

(6) Calculation of efficiency of solar module using artificial solar lighting.

1) Select the maximum output power value from the power curve above (4).
2) The efficiency of the module shall be compliant with the following standards : However, because it is an experiment using artificial sun, not natural sun, 1000 standard is omitted.(Since the energy content of the spectrum for solar cell generation is different from that of the natural and artificial sunlight, corrections using the simple solar irradiance are not accurate. However, if an experiment was conducted using natural sunlight, it should be corrected to the reference value of 1000.) Measure the surface temperature of the following solar module and adjust the maximum output power value by reflecting the module's temperature coefficient (at 25 ℃).($P_{\max}$)

eq. Maximum output power - {(current temperature - 25 ℃) × Power temperature coefficient} = Corrected maximum output power ($P_{\max}$)

3) Calculate the efficiency of solar cells

eq. $$Solar\ Cell\ Efficiency = \frac{P_{\max}}{P_{input}} \times 100(\%)$$

4. Electrical Characteristics of solar cell module

Electrical Specifications	
Rated Power(Wp)	230 W(±3%)
Max. Power Voltage(Vmp)	29.3 V
Max. Power Current(Imp)	7.84 A
Open Circuit Voltage(Voc)	37.1 V
Short Circuit Current(Isc)	8.42 A
Coefficient	
The coefficient of power	-0.405±0.05%/℃
The coefficient of voltage	-0.312±0.015%/ ℃
The coefficient of current	+0.075±0.015%/℃
*STC (1000W/m², AM: 1.5, 25 ℃)	
Product Specifications	
Dimensions	1642 X 979 X 38 mm
Solar Cells	60 Cell, 156mm x 156mm, 6 x 10 matrix connected in series
Maximum System voltage	1000 VDC

(1) Rated output (Wp)
(2) Max. Power Voltage(Vmp)
(3) Max. Power Current(Imp)
(4) Open Circuit Voltage(Voc)
(5) Short Circuit Current(Isc)
(6) The coefficient of power
(7) The coefficient of voltage
(8) The coefficient of current

* Irradiation 1KW/㎡, Room temperature. 25℃ Standar

5. Calculation of Power Generation using Temperature Characteristics of Solar Cell Module

Electrical Specifications	
Rated Power(Wp)	230 W(±3%)
Max. Power Voltage(Vmp)	29.3 V
Max. Power Current(Imp)	7.84 A
Open Circuit Voltage(Voc)	37.1 V
Short Circuit Current(Isc)	8.42 A
Coefficient	
The coefficient of power	-0.405±0.05%/℃
The coefficient of voltage	-0.312±0.015%/ ℃
The coefficient of current	+0.075±0.015%/℃
*STC (1000W/m², AM: 1.5, 25 ℃)	
Product Specifications	
Dimensions	1642 X 979 X 38 mm
Solar Cells	60 Cell, 156mm x 156mm, 6 x 10 matrix connected in series
Maximum System voltage	1000 VDC

(1) Module Output by Temperature Change

- Where the cell surface temperature is 25℃, the output value is 29.3V, 7.84A 230W

ex) Calculation method of voltage and power generation, when the cell surface temperature is 20℃

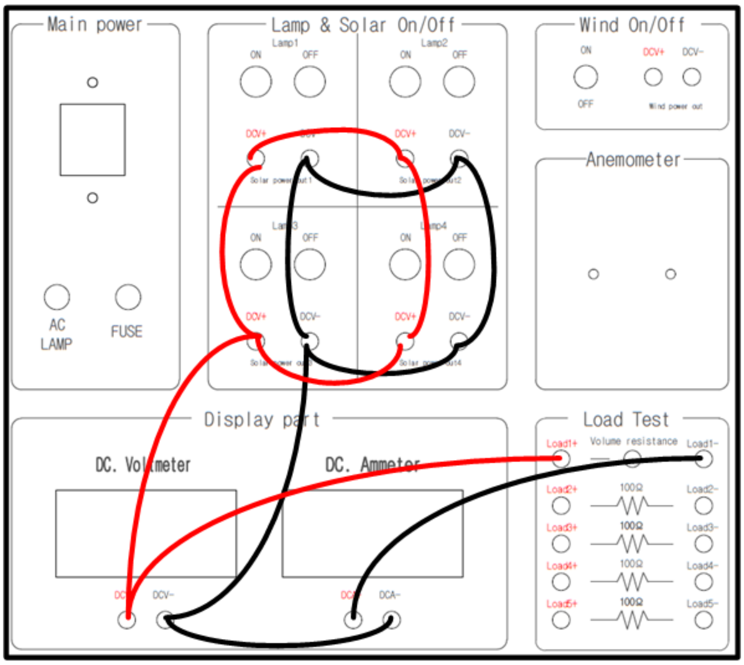
1) Vmp + {(Current Temperature-25 ℃) × Voltage Temperature Coefficient} = Output Voltage

a. 29.3V+{((20℃)- 25℃)) ×-0.312}
= 29.3 + 1.56= 30.86V

2) Wp + {(Current Temperature-25 ℃) × Voltage Temperature Coefficient} = Output Power

a. 29.3V*7.84A + (((20℃) - 25℃)×(-0.405)) = 229.71W + 2.025W
= 231.735W estimated

6. Connection wiring diagram



・Requirements

1. Prepare and inspect laboratory apparatus and tools.
2. Construct and operate a solar module efficiency circuit using experimental equipment and tools.
3. Measure the output voltage of the solar module and draw a graph.
4. Measure the output current of the solar module and draw a graph.
5. Calculate the resistance and power values using the voltage and current values of the solar module.
6. Measure and calculate using a pyranometer
7. Calculate the efficiency of solar modules.

<table>
<tr><td rowspan="8">Valuation Basis</td><td colspan="2">Evaluation Item</td><td>Allot</td><td>Obtain</td><td colspan="4">Remark</td></tr>
<tr><td rowspan="4">Item point (80)</td><td>Prepare the Solar Module Efficiency Experiment</td><td>20</td><td></td><td colspan="4" rowspan="6"></td></tr>
<tr><td>Voltage measurement and graphing</td><td>20</td><td></td></tr>
<tr><td>Current measurement and graphing</td><td>20</td><td></td></tr>
<tr><td>Calculation of Efficiency of Solar Module</td><td>20</td><td></td></tr>
<tr><td rowspan="2">Work point (10)</td><td>Work attitude and safety</td><td>10</td><td></td></tr>
<tr><td>Use, arrange, and dispose of materials tools</td><td>10</td><td></td></tr>
<tr><td>Time point (10)</td><td colspan="3">Subtract (   ) point in every (   ) minute excess</td><td>Item

</td><td>Work

</td><td>Time

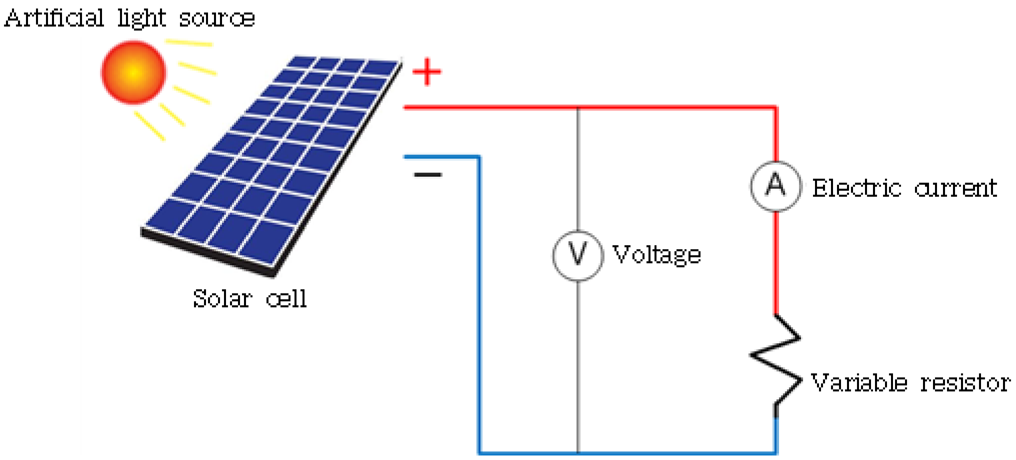
</td><td>Total

</td></tr>
</table>

Experiment name	2. An Experiment to Measure the Output Voltage and Current of solar Module According to Change in Solar Radiation	**Class time(hr)**	8
Object	① Measuring the output voltage and current of a solar module ② Describing the output characteristics of the solar module according to the load change ③ Describe the output characteristics of solar module according to the angle of incidence		

Experiment equipment	**Tool & material**	**Spec of tools**	**Q`nty**
• Hybrid Power Conversion Experiment Equipment (KTE-HB520N)	• Driver • Nipper • Wire stripper • Hook meter	• #2× 6× 175mm • 150mm • 0.5~6mm² • 300A 600V	1 1 1 1/Group

Control Circuit



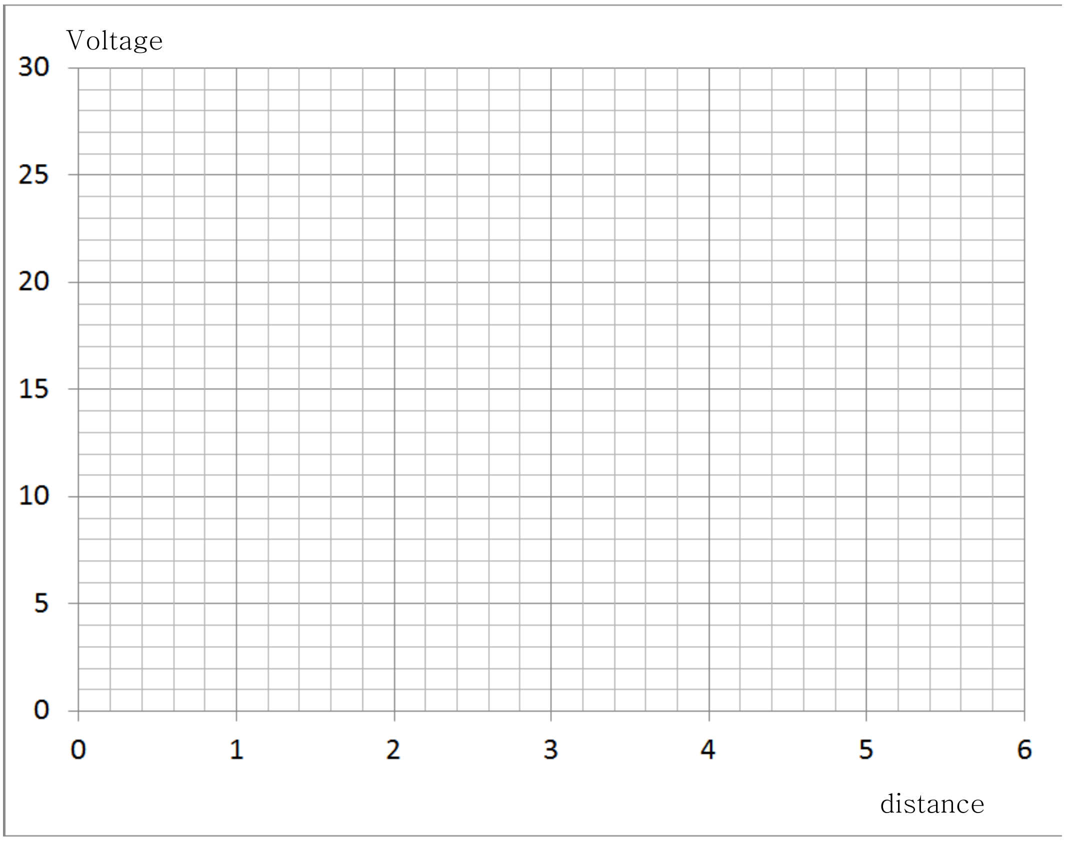
1) Circuit configuration
   (1) The circuit diagrams are connected with the wiring diagram above.
   (2) The load department can regulate consumption power through resistance control.
2) Experimental method
   (1) Power up the artificial light source and illuminate the solar module horizontally with the artificial light source at regular intervals.
   (2) Switch on the artificial light source.
   (3) Gradually change the resistance from load 0 through the variation of resistance to measure the changed voltage and current and calculate the power.

3. Measurement experiment

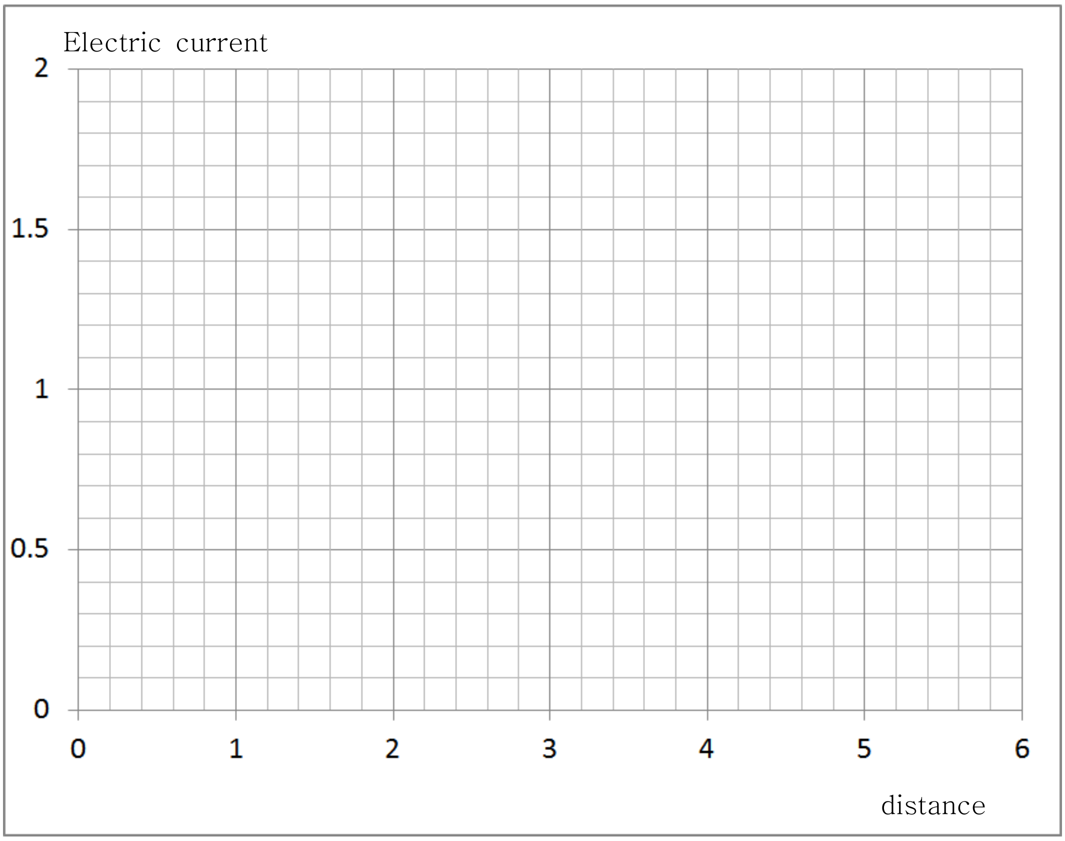
(1) Measure voltage V, current I (A) values below and Calculate the power and resistance values in the table

distance	1	2	3	4	5	6
V						
I(A)						
R(Ω)						
P(W)						

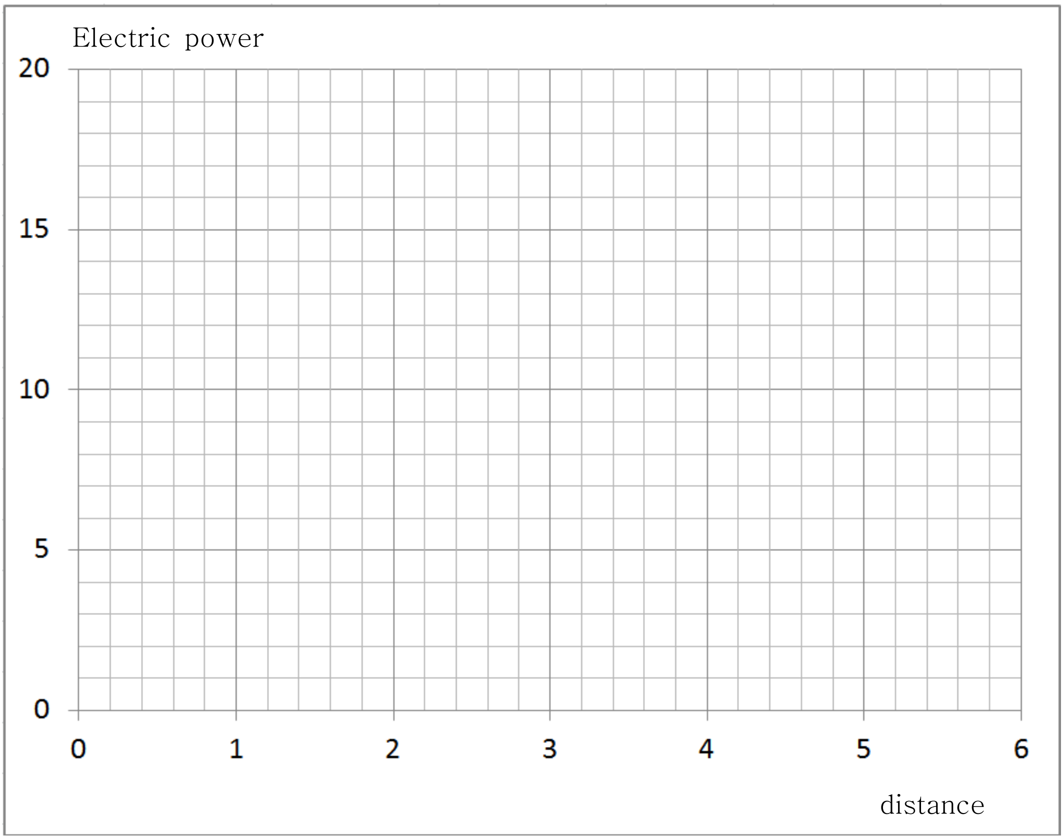
(2) Draw a voltage (V) curve.



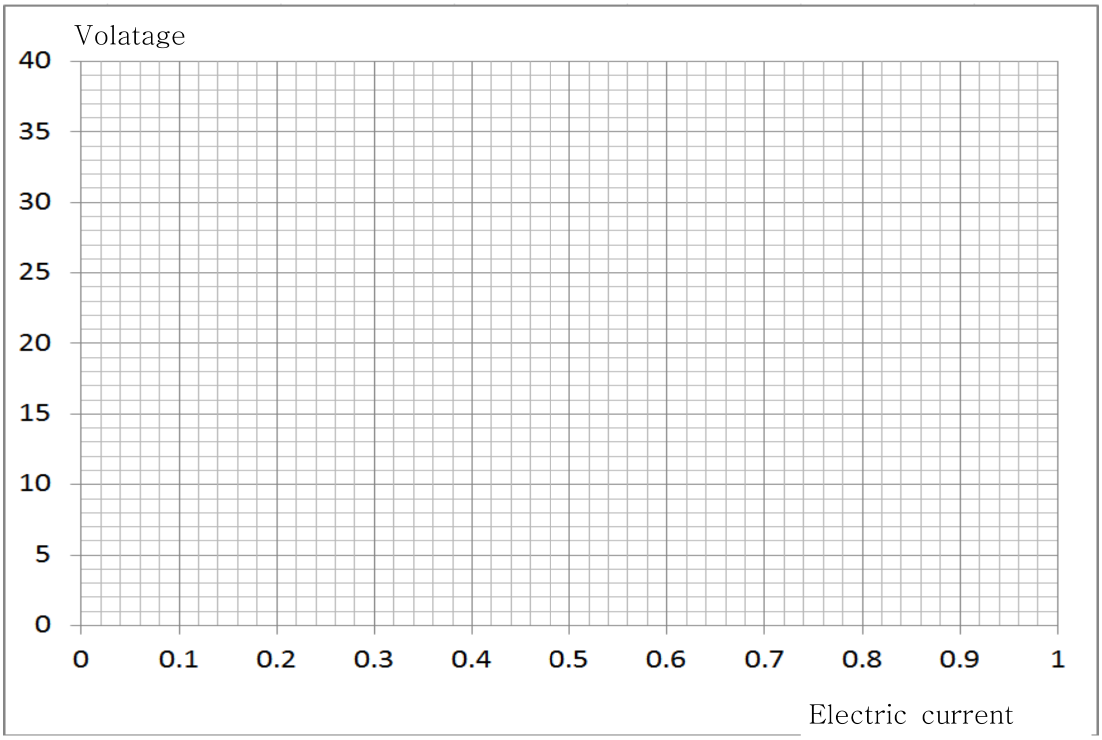
(3) Draw current (I) curve.



(4) Draw a curve of power (W).



(5) Draw a V-I curve.



・Requirements

1. Prepare and inspect laboratory apparatus and tools.
2. Construct and operate a solar module efficiency circuit using experimental equipment and tools.
3. Measure the voltage (V) and draw a graph according to the angular changes in the solar module.
4. Measure the current (A) and draw a graph according to the angular changes of the solar module.
5. Calculate the power value using the voltage and current values of the solar module.
6. Explain the power generation according to the incidence of solar modules.

<table>
<tr><td rowspan="9">Valuation Basis</td><td colspan="2">Evaluation Item</td><td>Allot</td><td>Obtain</td><td colspan="4">Remarks</td></tr>
<tr><td rowspan="4">Item point (80)</td><td>Prepare the Solar Module Characteristics Experiment</td><td>20</td><td></td><td colspan="4" rowspan="6"></td></tr>
<tr><td>Voltage measurement and graphing</td><td>20</td><td></td></tr>
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<tr><td>Graph construction based on power value calculation</td><td>20</td><td></td></tr>
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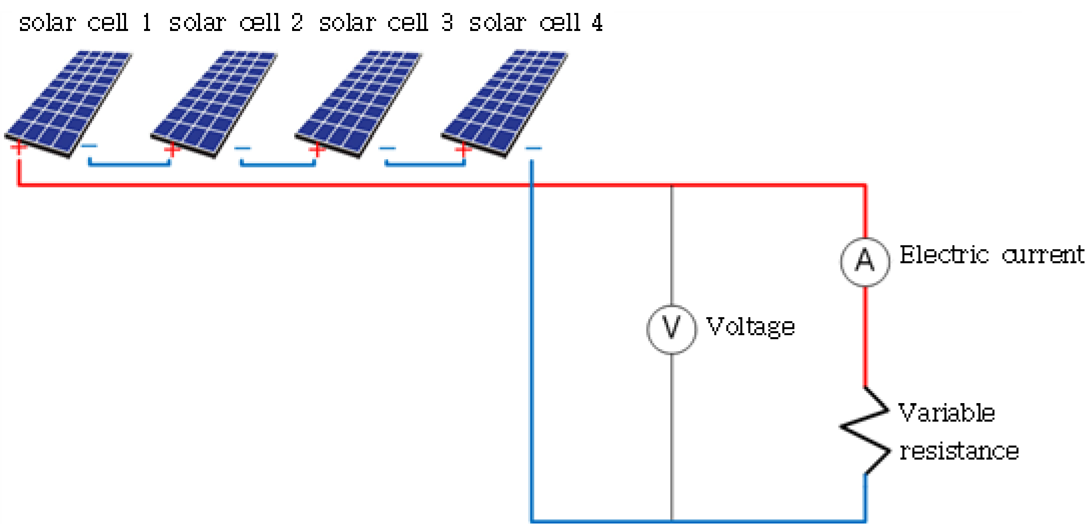
<tr><td>Use, arrange, and dispose of materials tools</td><td>5</td><td></td></tr>
<tr><td rowspan="2">Time point (10)</td><td colspan="3" rowspan="2">Subtract (   ) point in every (   ) minute excess</td><td>Item</td><td>Work</td><td>Time</td><td>Total</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
</table>

Experiment name	3. An Experiment to Measure the Output Voltage and Current of Solar Module According to the Direct and Parallel Connections of a Module	**Class time(hr)** 8
Object	① Measure the output voltage, current, of the solar module ② Describe the output characteristics of solar module according to the load change ③ Describe the output characteristics of solar modules according to serial and paralle l connections of modules	

Experiment equipment	**Tool & material**	**Spec of tools**	**Q`nty**
· Hybrid Power Conversion Experiment Equipment (KTE-HB520N)	· Driver · Nipper · Wire stripper · Hook meter	· #2× 6× 175㎜ · 150㎜ · 0.5~6㎟ · 300A 600V	1 1 1 1/Group

Control Circuit



1) Circuit configuration

(1) The circuit diagrams are connected with the wiring diagram above.

(2) The load department can regulate consumption power through resistance control.

2) Experimental method

(1) Power up the artificial light source and illuminate the solar module horizontally with the artificial light source at regular intervals.

(2) Switch on the artificial light source.

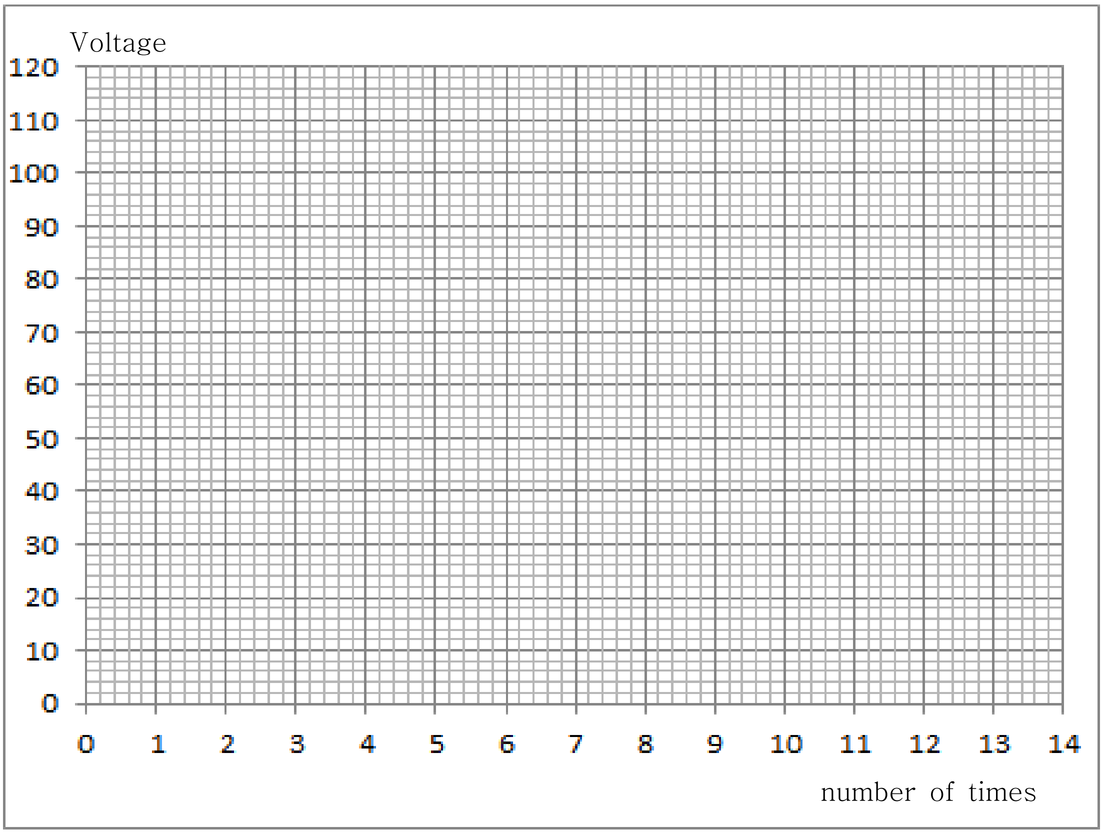
(3) Gradually change the resistance from load 0 through the variation of resistance to measure the changed voltage and current and calculate the power.

3. Experiment with measurement after connecting sunlight modules in series

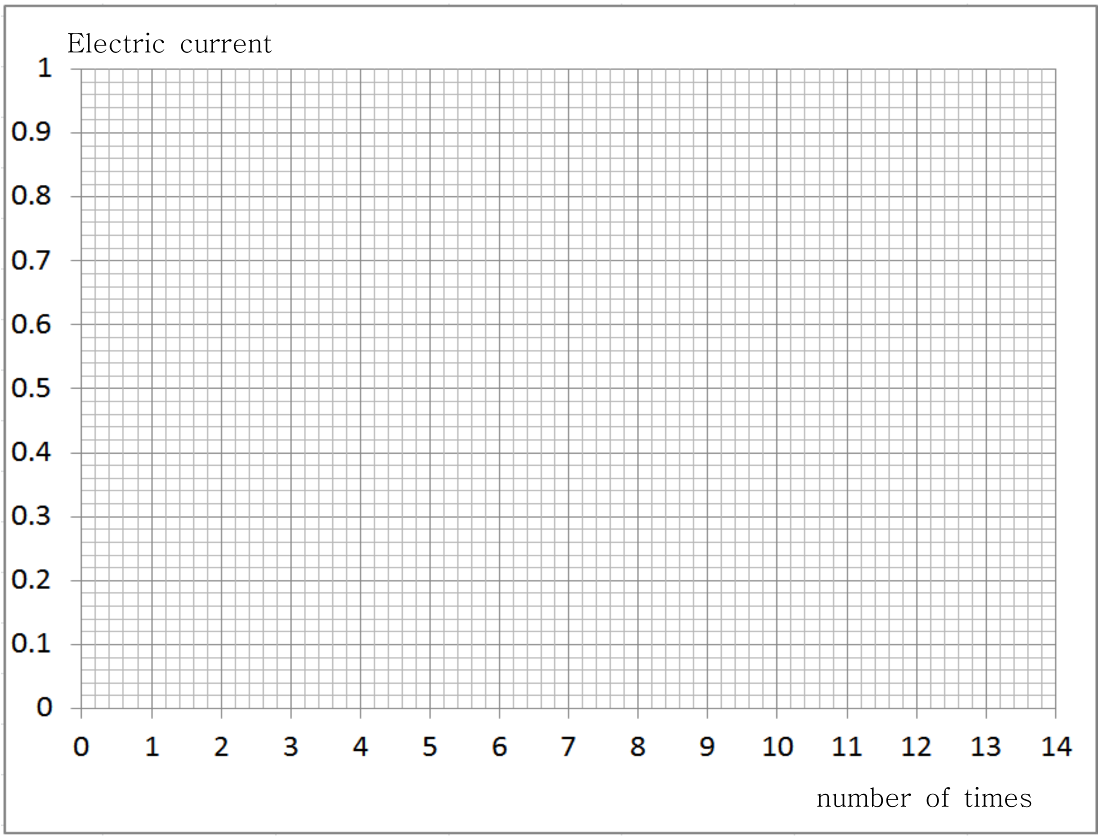
(1) Measure voltage V, current I (A) values below and Calculate the power and resistance values in the table

number	1	2	3	4	5	6	7	8	9	10	11	12	13	14
V														
I(A)														
R(Ω)														
P(W)														

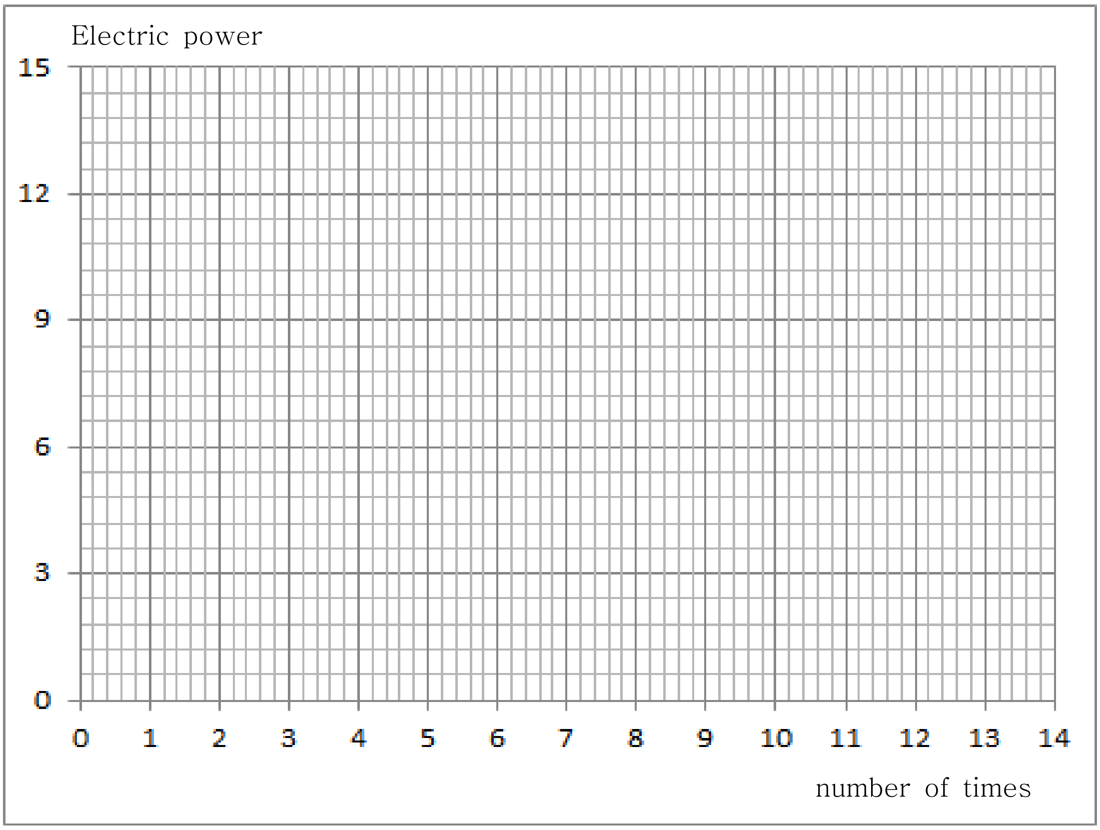
(2) Draw a voltage (V) curve.



(3) Draw current (I) curve.

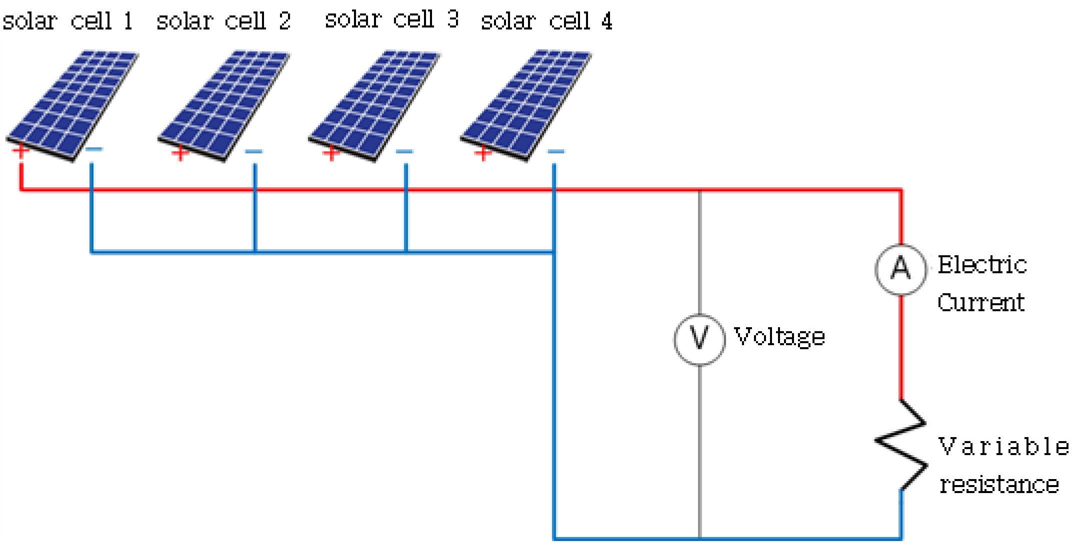


(4) Draw a curve of power (W).



4. Experiment with solar module after connecting them in parallel

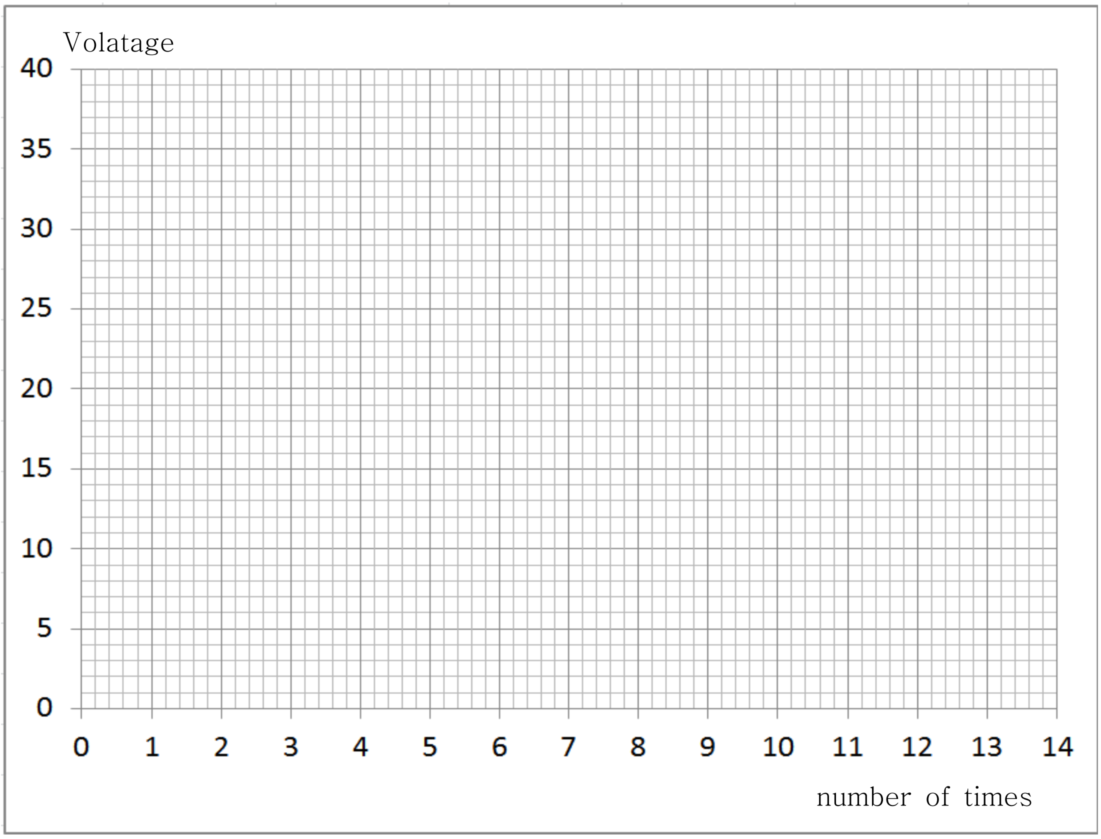
- Circuit diagram



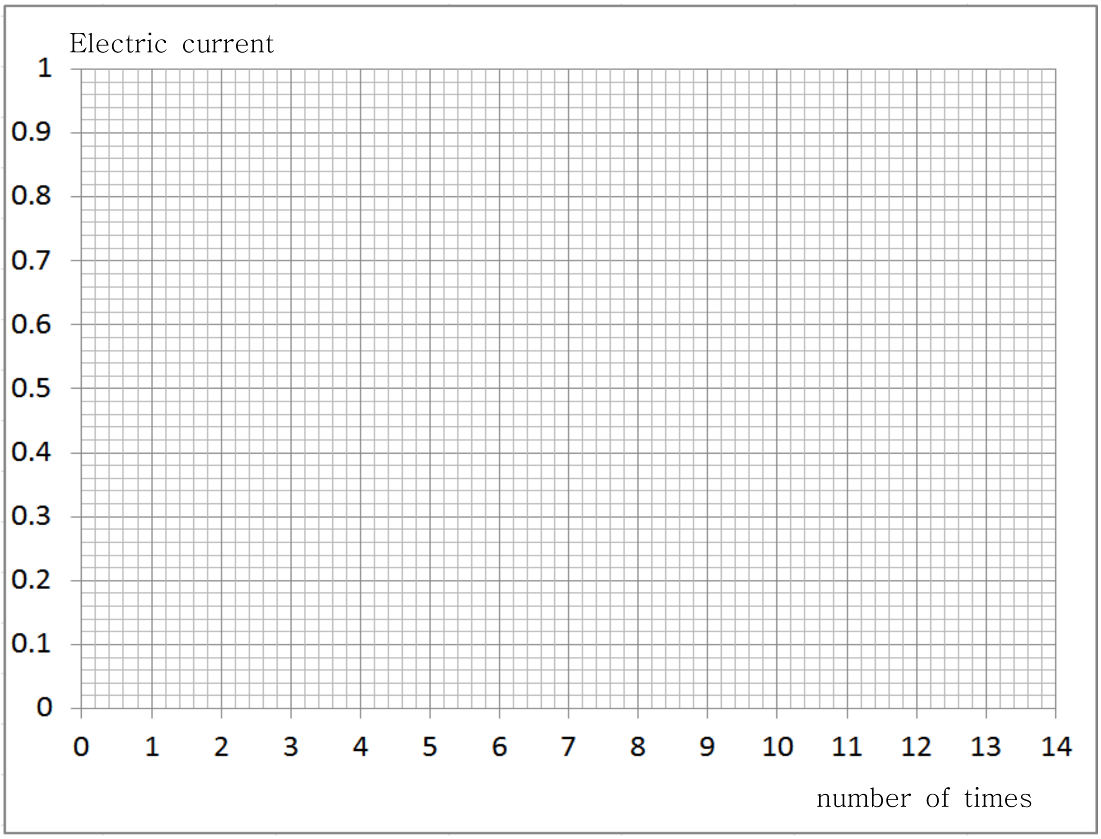
(1) Mark in the table below the measured voltage V, current I (A) value and calculate the power and resistance

number	1	2	3	4	5	6	7	8	9	10	11	12	13	14
V														
I(A)														
R(Ω)														
P(W)														

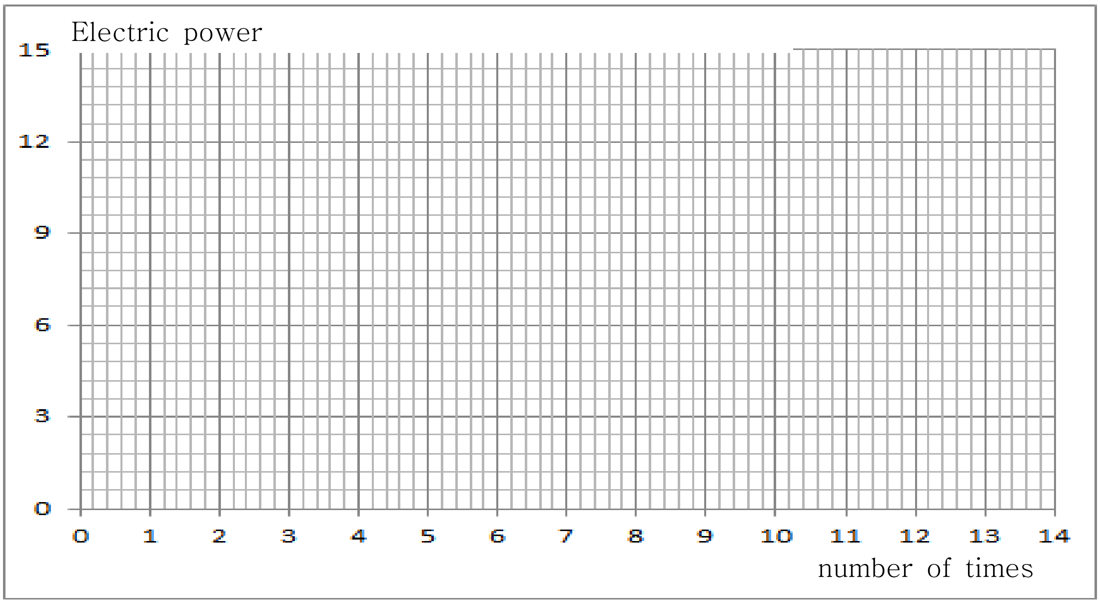
(2) Draw a voltage (V) curve.



(3) Draw current (I) curve.



(4) Draw and compare series and parallel connecting power (W) curves.



・Requirements

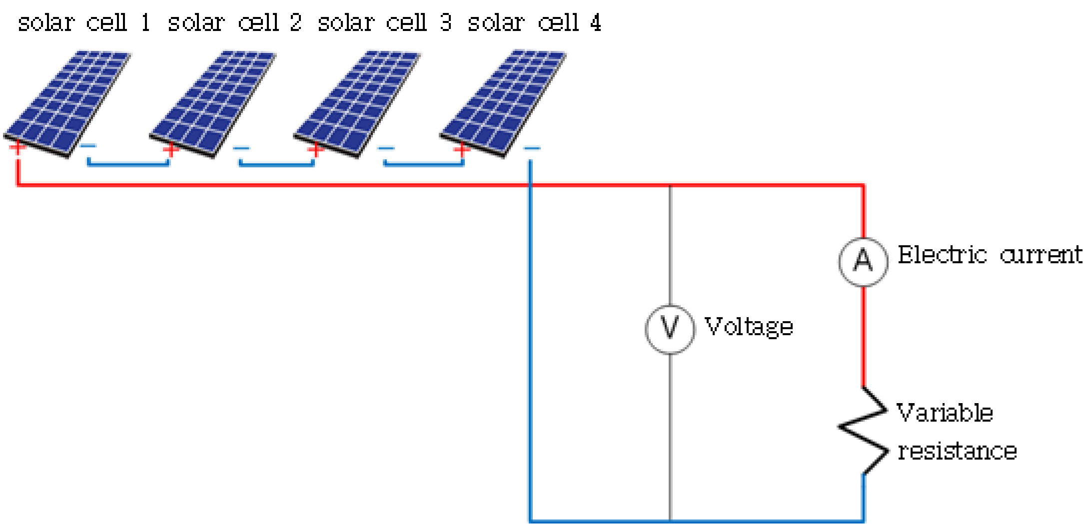
1. Prepare and inspect laboratory apparatus and tools.
2. Construct and operate a solar module efficiency circuit using experimental equipment and tools.
3. Measure the voltage (V) and current (A) after connecting the solar module in series and draw a graph.
4. After connecting the solar module in parallel, measure the voltage (V), current (A), and draw a graph.
5. Using the voltage and current values of the solar module, compare and explain the power values of the series and parallel connections.
6. Explain the power generation resulting from the direct and parallel connection of solar modules

Valuation Basis	Evaluation Item		Allot	Obtain	Remarks			
	Item point (80 point)	Prepare the Solar Module Characteristics Experiment	20					
		Voltage measurement and graphing	20					
		Current measurement and graphing	20					
		Graph construction based on power value calculation	20					
	Work point (10 point)	Work attitude and safety	5					
		Use, arrange, and dispose of materials tools	5					
	Time point (10 point)	Subtract ( ) point in every ( ) minute excess			Item	Work	Time	Total

Experiment name	4. Experiment on the output voltage and current measurement of solar module according to shade when a module is connected directly or in parallel	Class time(hr)
		8
Object	① Measure the output voltage, current, of the solar module ② Describe the output characteristics of solar module according to the load change ③ Describe shadow characteristics of solar module according to serial and parallel connections of module	

Experiment equipment	Tool & material	Spec of tools	Q`nty
· Hybrid Power Conversion Experiment Equipment (KTE-HB520N)	· Driver · Nipper · Wire stripper · Hook meter	· #2× 6× 175㎜ · 150㎜ · 0.5~6㎟ · 300A 600V	1 1 1 1/Group

Control Circuit



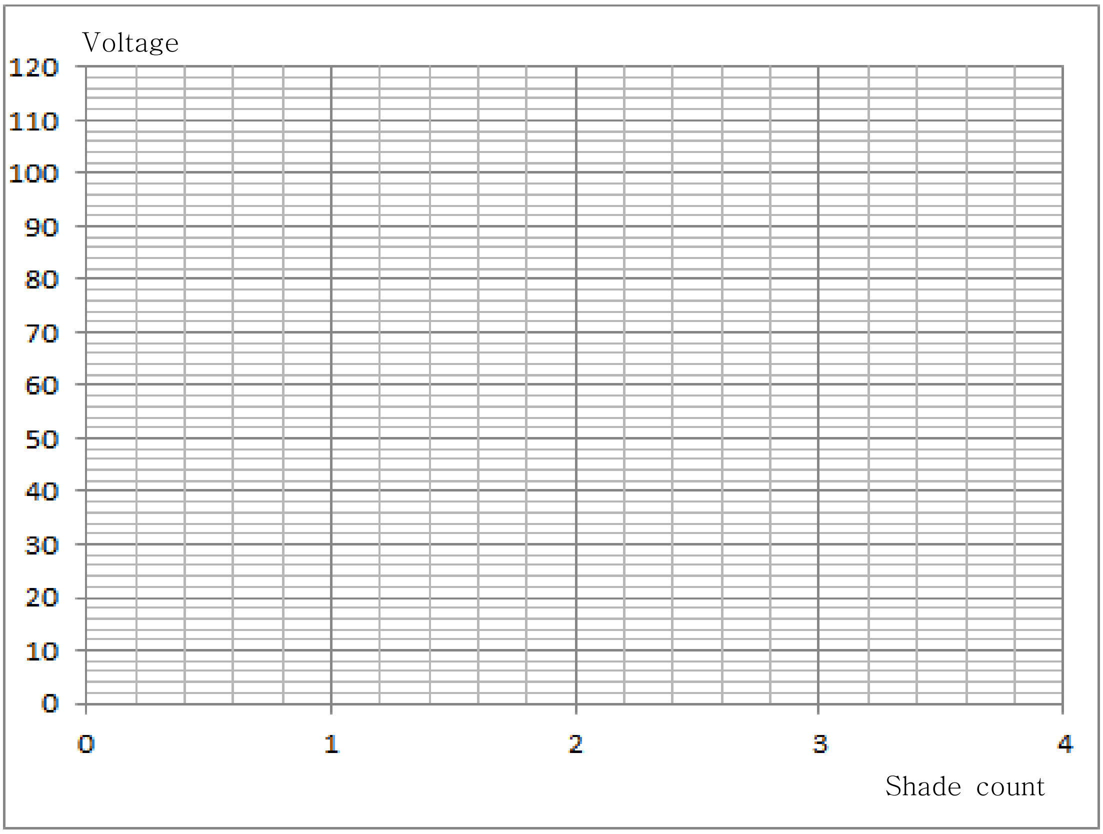
1) Circuit configuration
   (1) Connect the solar module in series or in parallel.
   (2) The load is controlled by varying resistance.
2) Experimental method
   (1) Power up the artificial light source and shine the solar module horizontally.
   (2) Connect the solar modules in series to conduct an experiment by shading them in order.
   (3) Connect the solar modules in parallel to each other to shade them in order.

3. Experiment with measurement after connecting sunlight modules in series

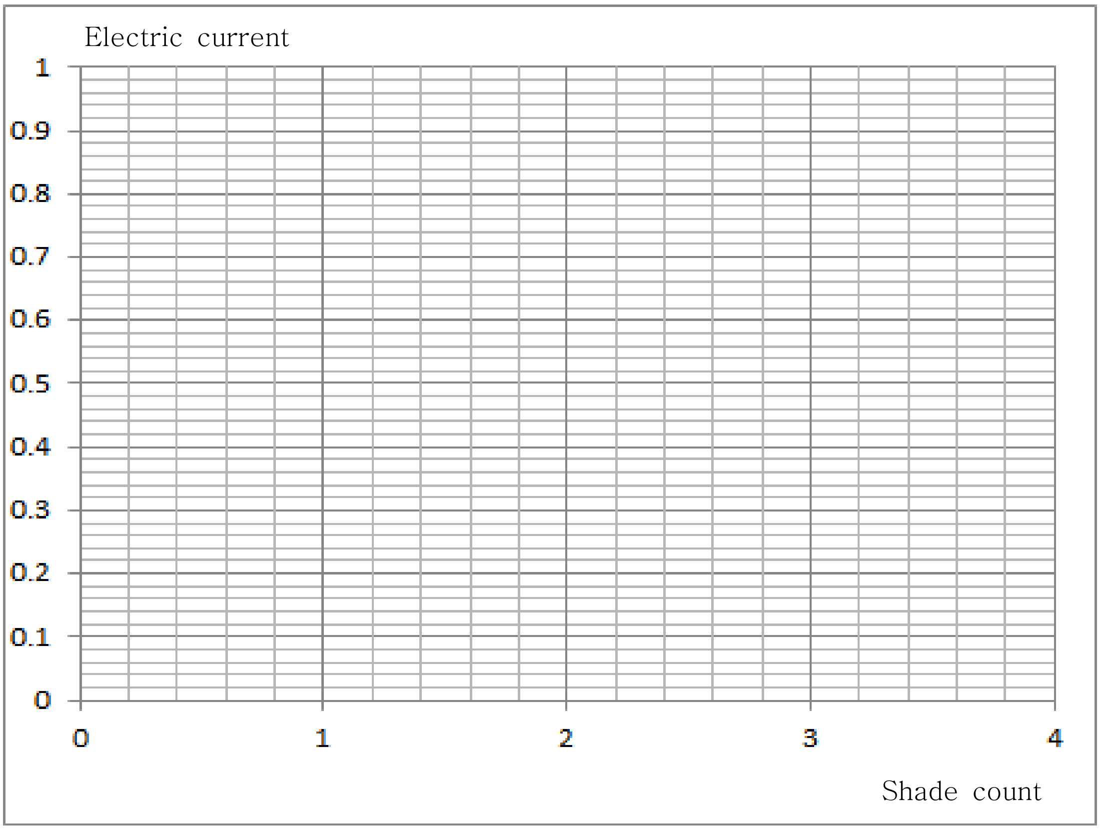
(1) Mark in the table the measured voltage V, current I (A) and calculate the power and resistance.

shading count	0	1	2	3
V				
I(A)				
R(Ω)				
P(W)				

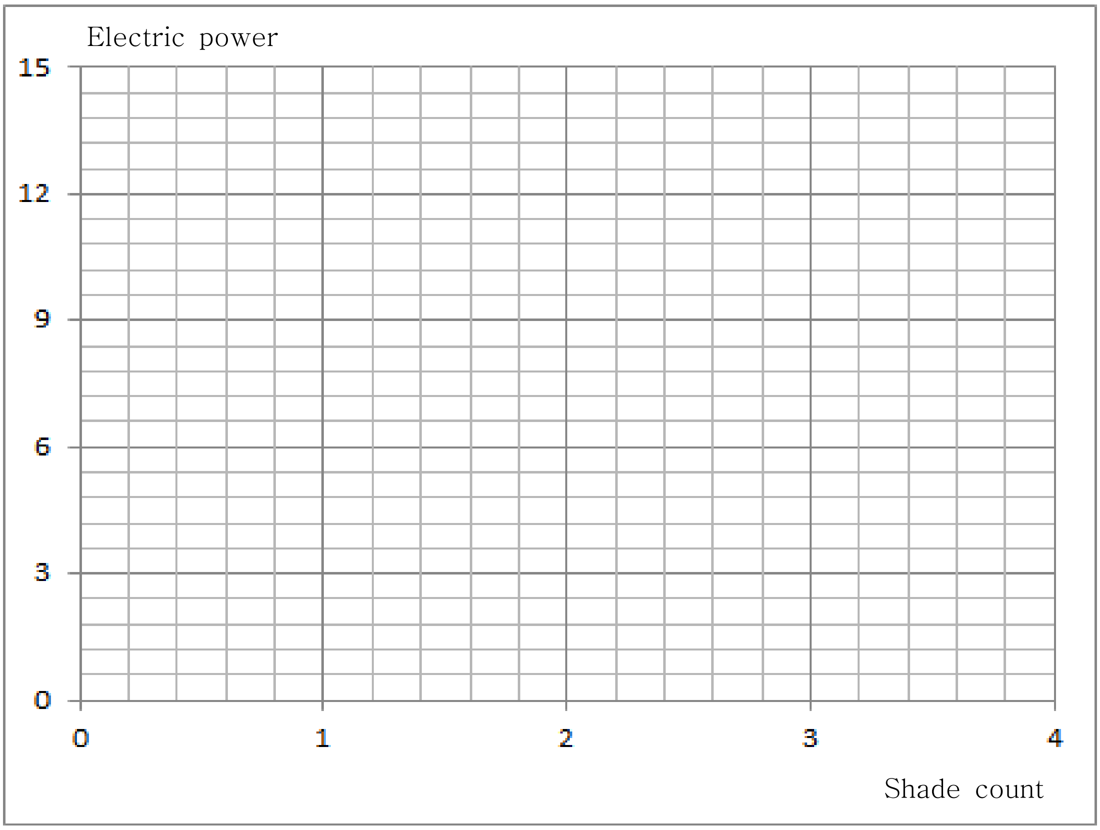
(2) Draw a voltage (V) curve.



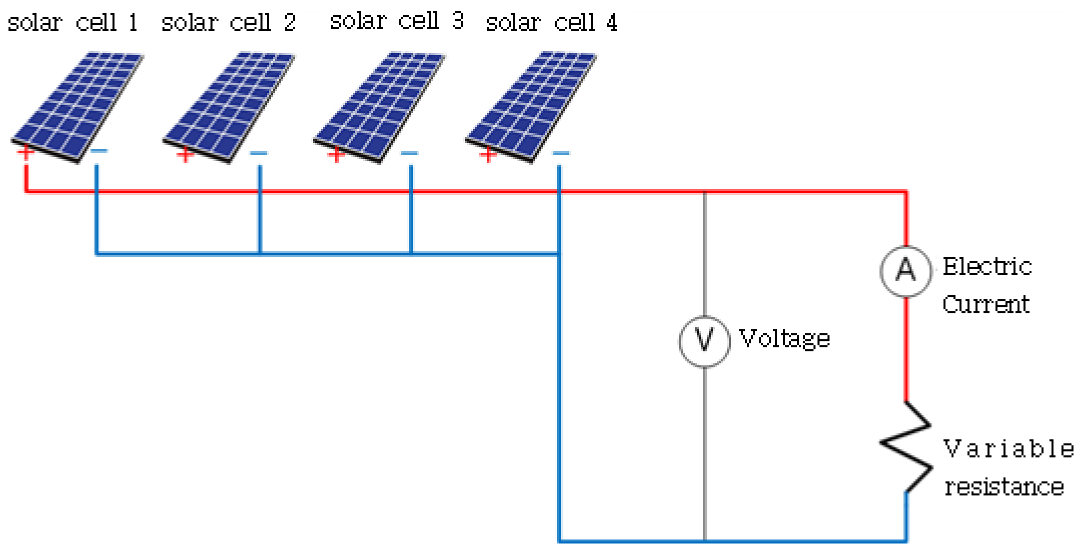
(3) Draw current (I) curve.



(4) Draw a curve of power (W).



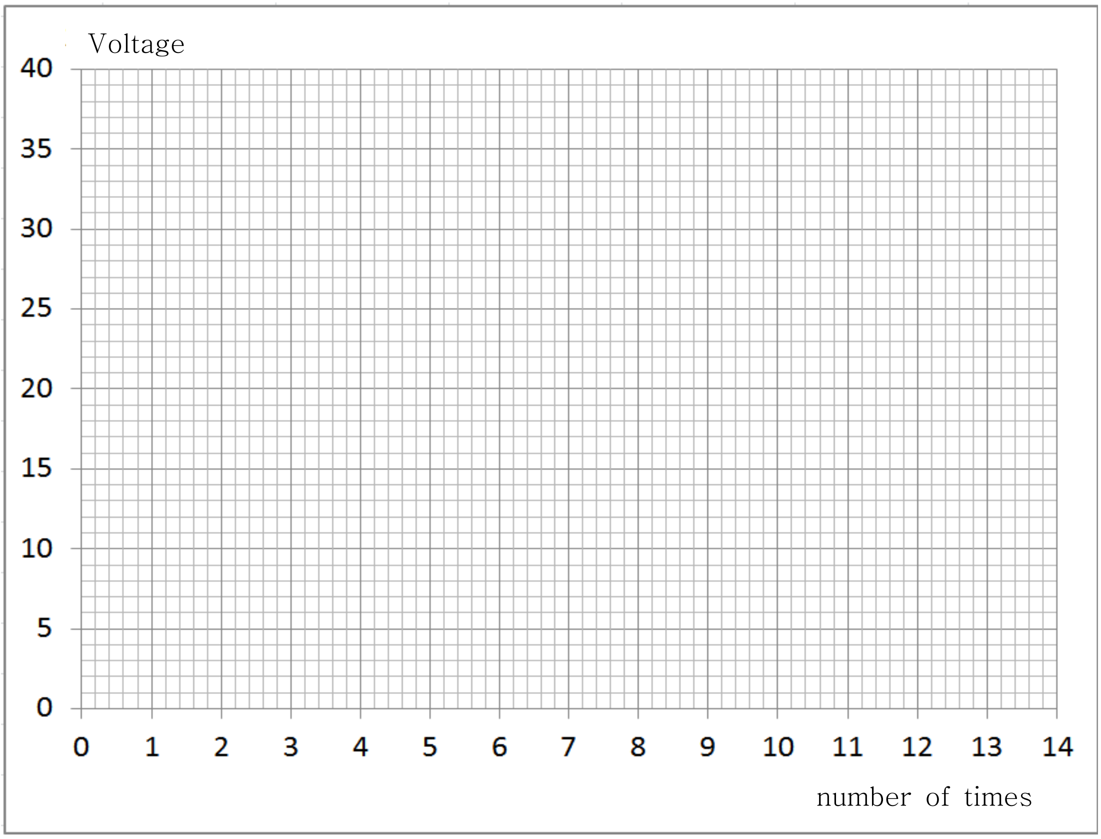
4. Experiment with solar module after connecting them in parallel



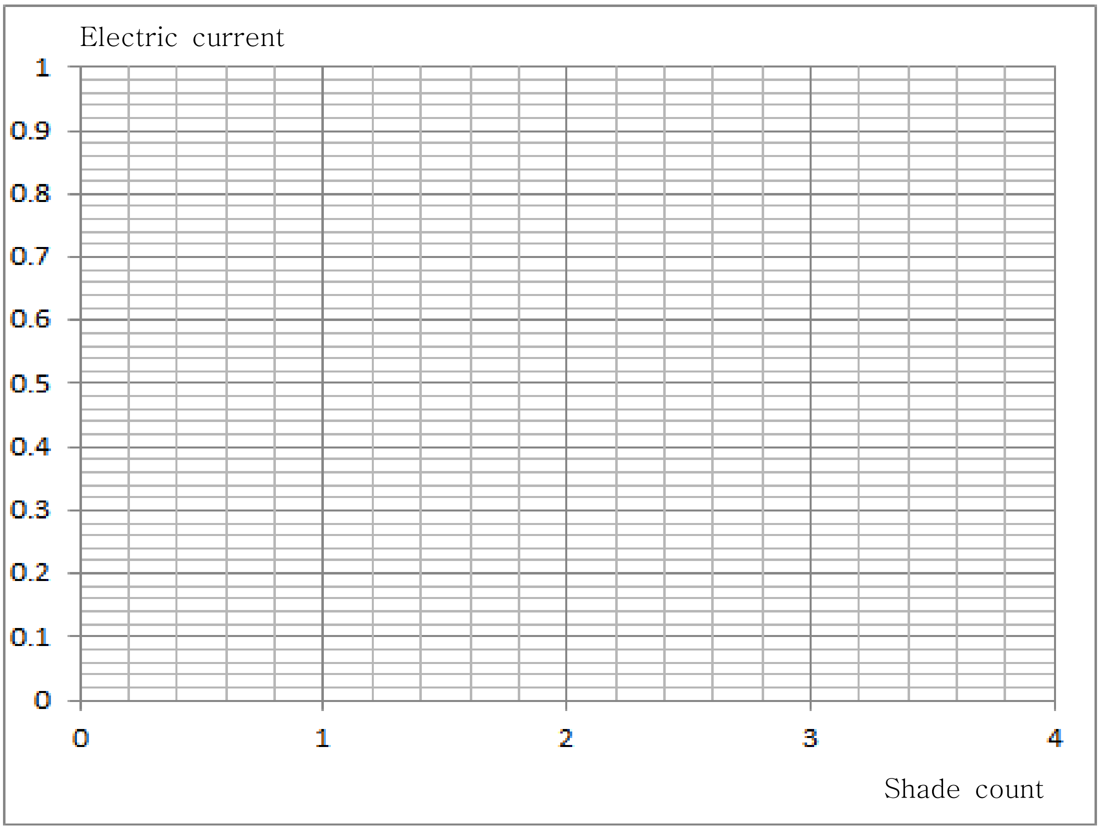
(1) Mark in the table the measured voltage V, current I (A) and calculate the power and resistance.

number	1	2	3	4	5	6	7	8	9	10	11	12	13	14
V														
I(A)														
R(Ω)														
P(W)														

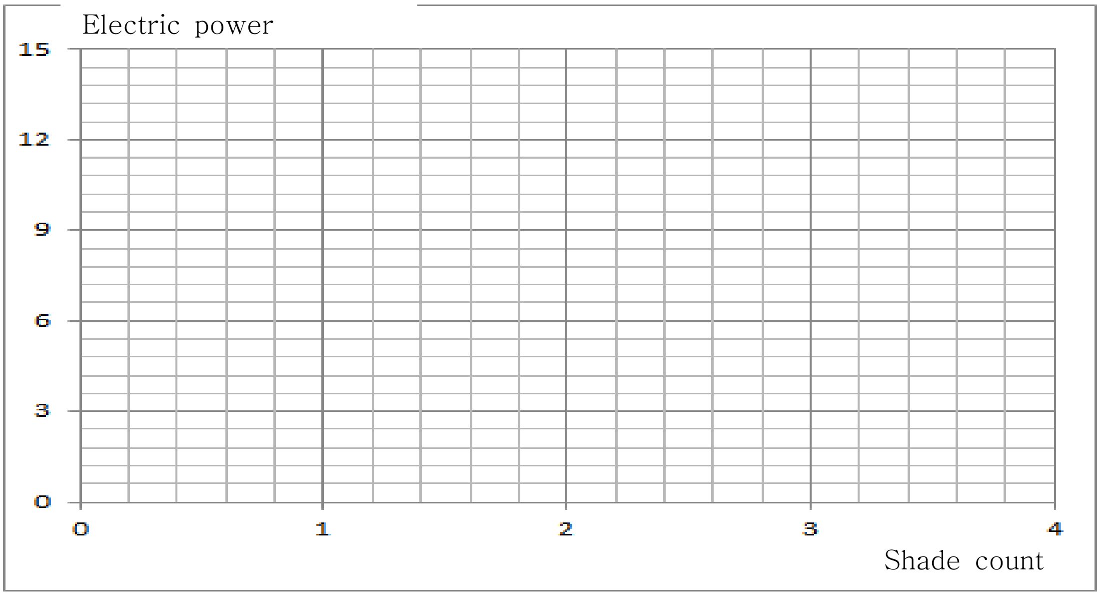
(2) Draw a voltage (V) curve.



(3) Draw an electric current (I) curve.



(4) Compare the series and parallel connection power (W) curves.



· Requirements

1. Prepare and inspect laboratory apparatus and tools.
2. Construct and operate a solar module efficiency circuit using experimental equipment and tools.
3. Measure the voltage (V) and current (A) after connecting the solar module in series and draw a graph.
4. After connecting the solar module in parallel, measure the voltage (V), current (A), and draw a graph.
5. Using the voltage and current values of the solar module, compare and explain the power values of the series and parallel connections.
6. Explain the power generation resulting from the direct and parallel connection of solar modules

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<tr><td>Voltage measurement and graphing</td><td>20</td><td></td></tr>
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<tr><td>Use, arrange, and dispose of materials tools</td><td>5</td><td></td></tr>
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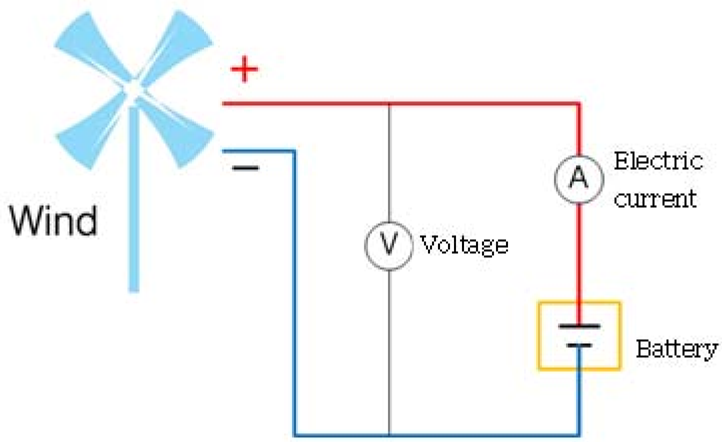
<tr><td></td><td></td><td></td><td></td></tr>
</table>

Experiment name	5. An Experiment to Measure the Efficiency of Wind Turbine Generator System by the Wind Speed			Class time(hr)
				8
Object	① The output voltage and current of the wind generator can be measured. ② Describe the Characteristics of Wind Power Generator System According to the Wind Speed Change ③ Calculate the efficiency of the wind generator			
Experiment equipment		Tool & material	Spec of tools	Q`nty
· Hybrid Power Conversion Experiment Equipment (KTE-HB520N)		· Driver · Nipper · Wire stripper · Hook meter	· #2× 6× 175㎜ · 150㎜ · 0.5~6㎟ · 300A 600V	1 1 1 1/Group

Control Circuit



1) Circuit configuration

(1) The wind-generator output section wiring to wind generator output section

(2) Connect it from the Wind Generator Output of the power conversion unit to the W.IN port of the Charge Controller, and from Charge Controller OUT to the Output Battery IN port of the Charge Controller to use the generator connection.

2) Experimental method

(1) Wind speed is controlled by adjusting the speed of the fan to operate the wind generator.

(2) Record the measured wind speed on the anemometer.

(3) Note the power value of the wind generator according to the change in wind speed values.

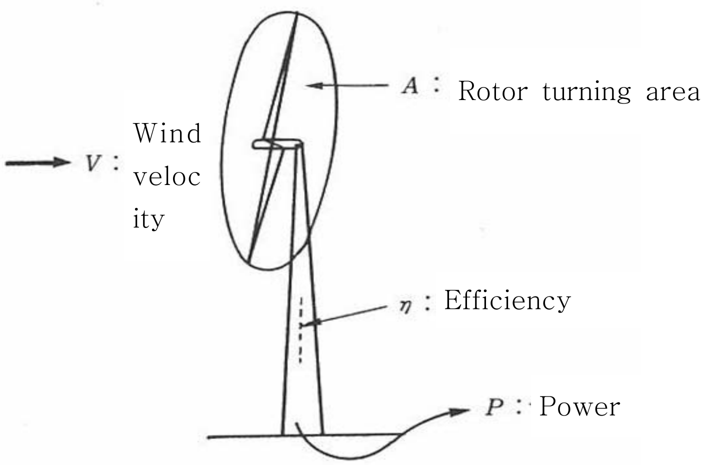
3. Experiment by connecting a wind generator to a power converter and adjusting its wind speed.

(1) Measure voltage V, current I (A) values and Calculate the power and efficiency values

number	1	2	3	4	5	6	7	8
Wind velocity (m/s)								
V								
I(A)								
P(W)								
Efficiency (η)								

(2) How to Calculate Wind Power Efficiency

The output of a wind power system is proportional to the density of air and to the three square meters of wind, and to the total efficiency of the rotor revolution and the total efficiency of the windmill, as shown in the following figures.



$$P = \frac{1}{2} \rho V^3 \cdot \eta \cdot A$$

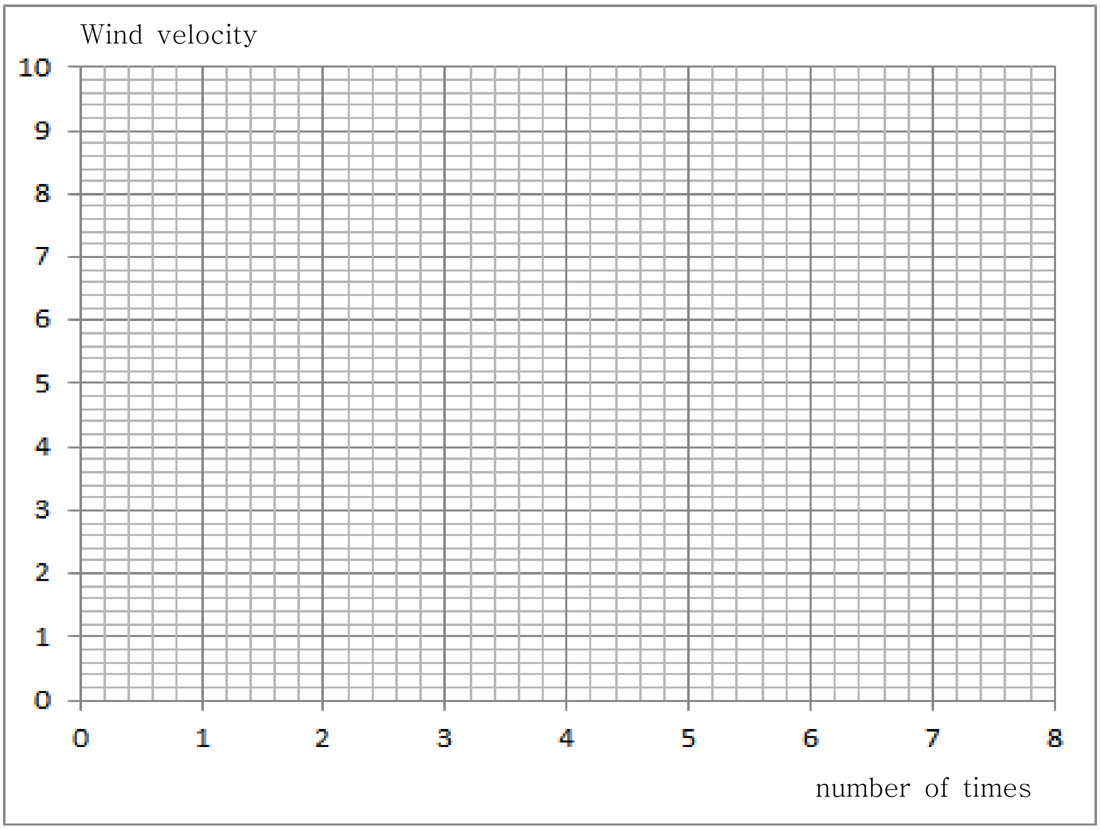
P: Output(W), ρ :Air density(1 atmosphere at 20 ℃, ρ = 1.205 kg / ㎥)

η: Percentage efficiency, A : Rotor turning area(m)

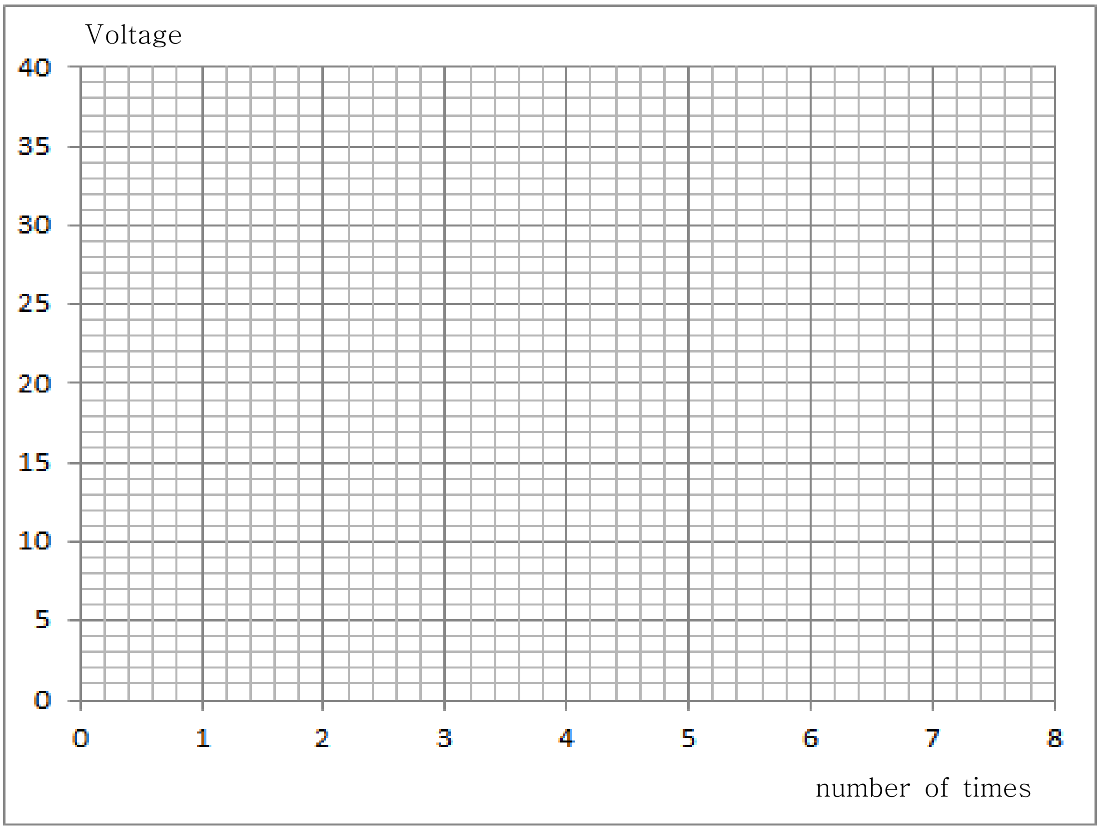
then, The wind generator efficiency calculation formula is as follows.

$$\eta = \frac{2 \cdot P}{\rho \cdot V^3 \cdot A} \times 100(\%)$$

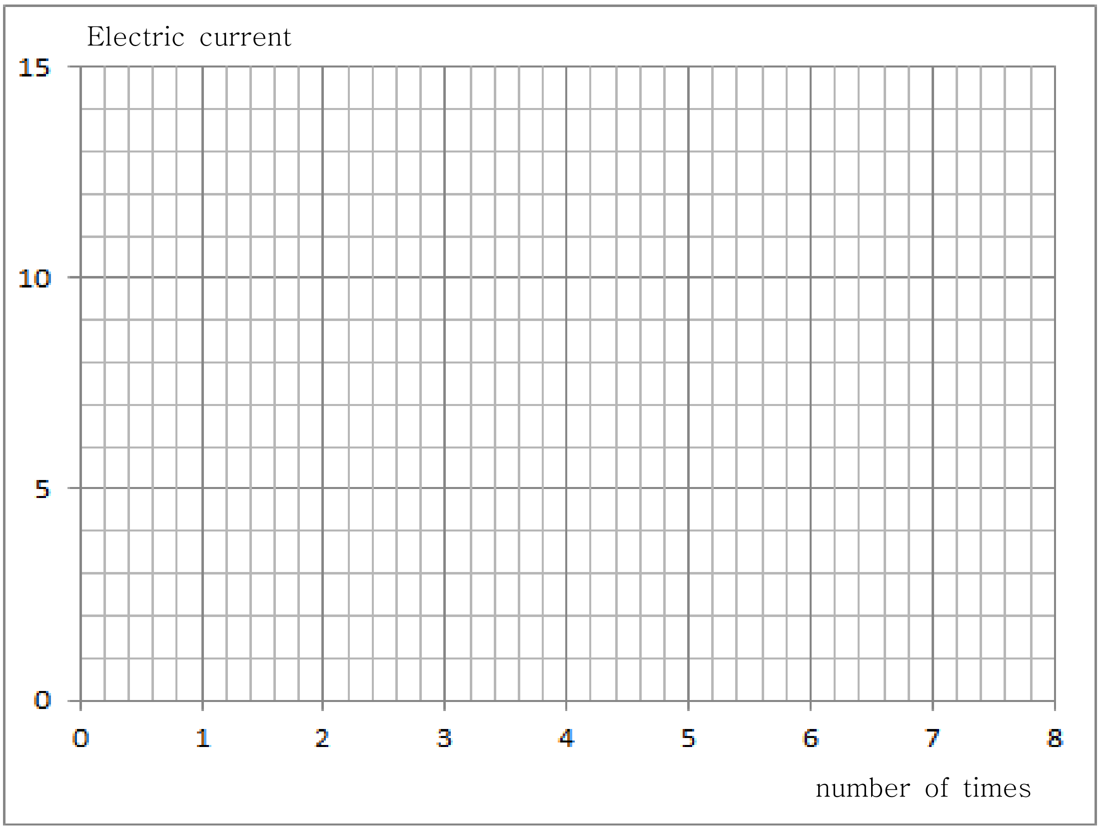
(2) Draw a curve of wind speed (m/s).



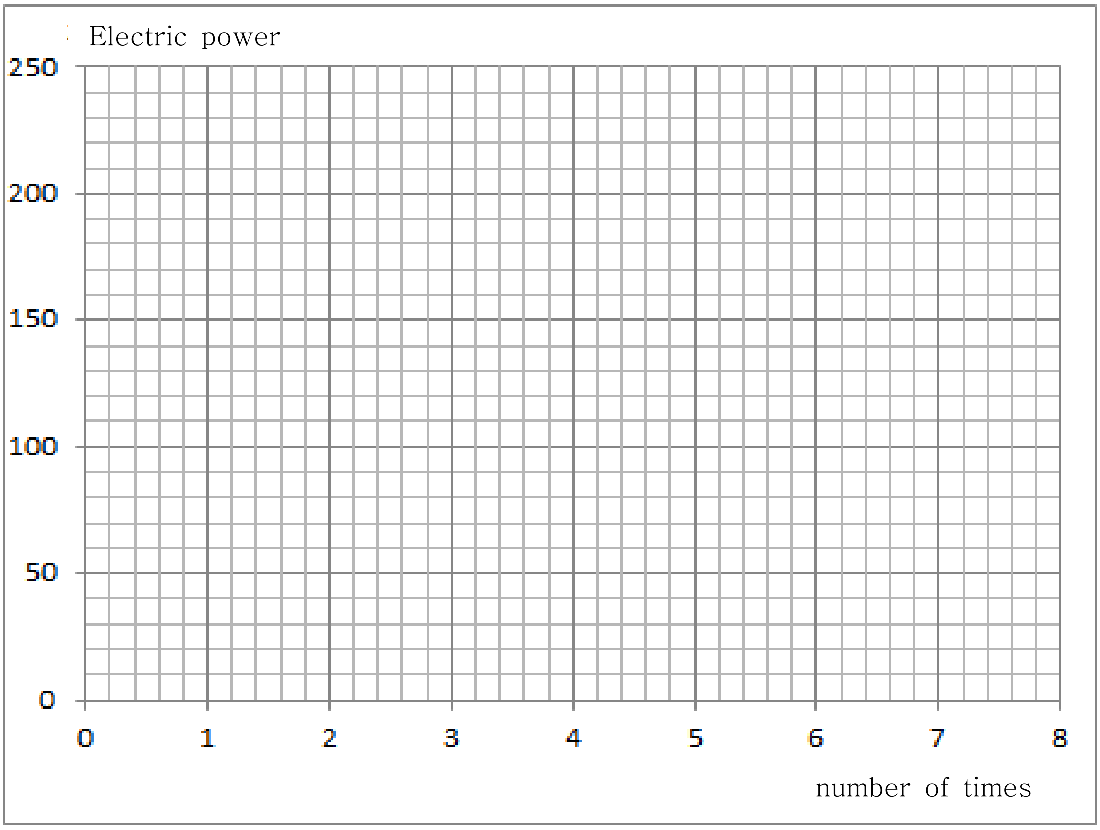
(3) Draw a voltage (V) curve.



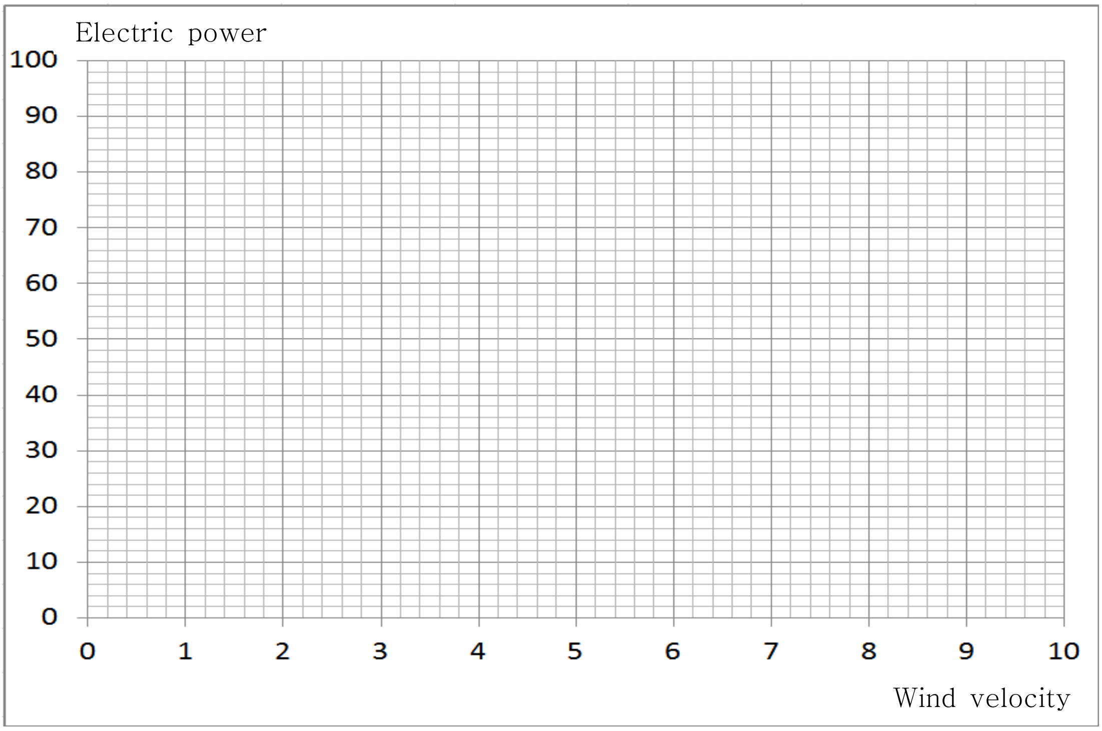
(4) Draw current (I) curve.



(5) Draw and compare the power (W) curves.



(5) Draw a curve of power (W) according to the wind speed (m/s).



・Requirements

1. Prepare and inspect laboratory apparatus and tools.
2. Using laboratory equipment and tools, construct and operate a wind generator effective meat circuit.
3. After starting the wind generator, measure the voltage (V), current (A), and draw a graph.
4. Calculate the power value of the wind generator and calculate the efficiency.
5. Compare and explain the power value of wind speed generator.
6. Describe wind generator system configuration

<table>
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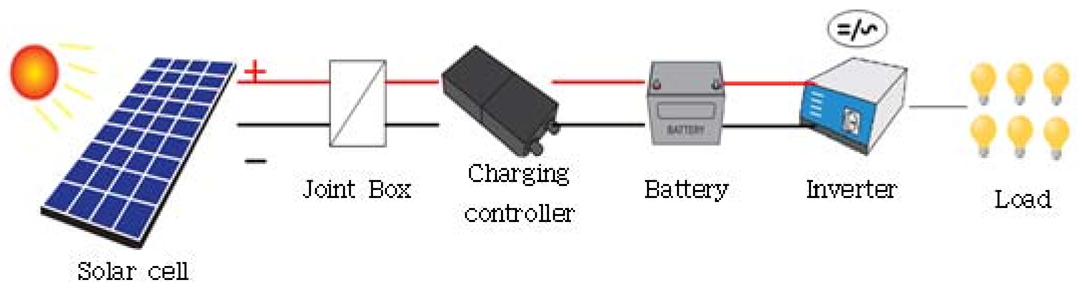
<tr><td rowspan="2">Time point
(10 point)</td><td colspan="3" rowspan="2">Subtract (　　) point in every (　　) minute excess</td><td>Item</td><td>Work</td><td>Time</td><td>Total</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
</table>

Experiment name	6. Practice of configuration of stand-alone inverter	Class time(hr)
		8
Object	① Understanding Stand-alone inverter Systems ② A Study on the Development of Stand-alone inverter System ③ An Experimental Study on the Stand-alone Inverter System	

Experiment equipment	Tool & material	Spec of tools	Q`nty
· Hybrid Power Conversion Experiment Equipment (KTE-HB520N)	· Driver · Nipper · Wire stripper · Hook meter	· #2× 6× 175㎜ · 150㎜ · 0.5~6㎟ · 300A 600V	1 1 1 1/Group

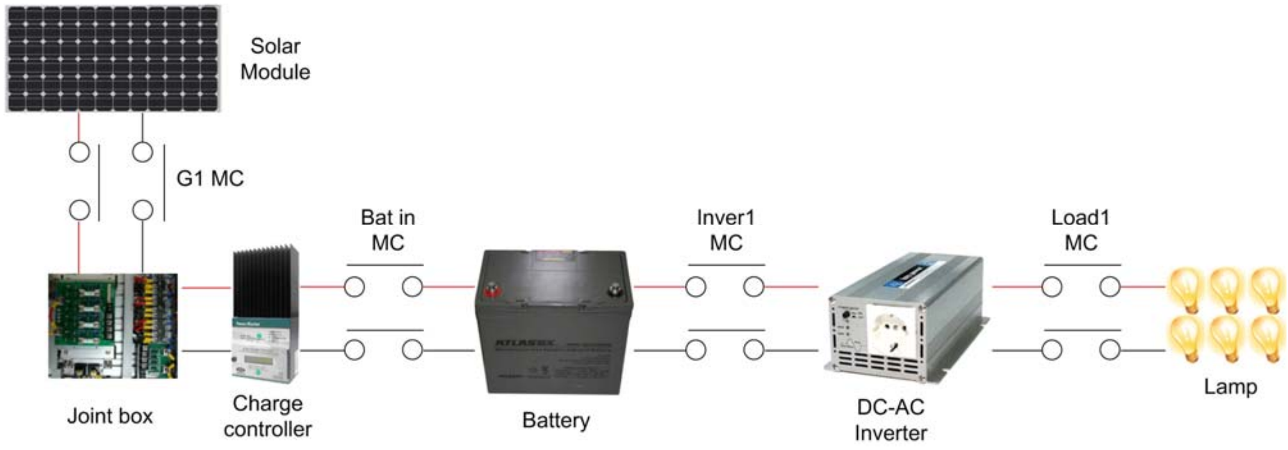
Control Circuit



1. Circuit configuration
   (1) Connect the solar module to the junction box by connecting it series or parallel connection.
   (2) Connect the charging controller from the connection board.
   (3) Connect it to the battery from the charging controller.
   (4) Connect the battery to the inverter.
   (5) Connect to the load from the inverter.

2. Experimental method
   (1) Connect the banana jack to the bottom of the control panel and select each load capacity.
   (2) Measure the battery discharge voltage, current value according to the load capacity and calculate the power value.

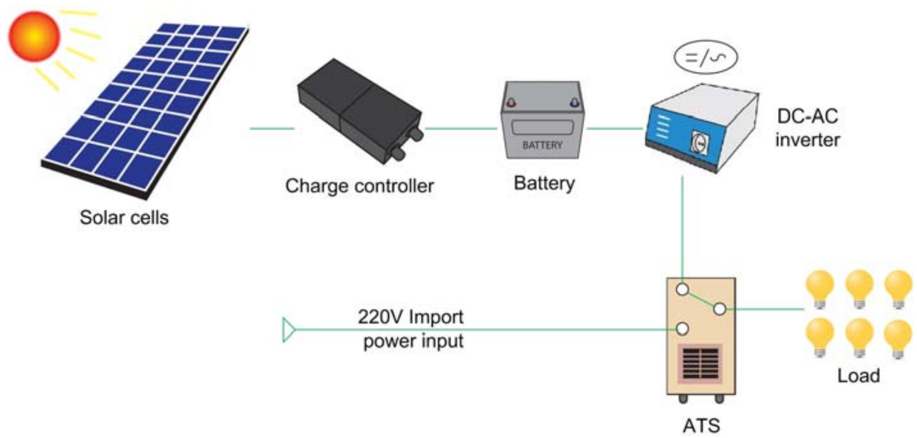
3. System description



4. Joint box

DC connection board is a device, which is made of a single string connected with multiple solar cell modules with different capacities, to supply direct current voltage generated from such modules to an inverter. Located and used within an inverter, the major component of photovoltaic and wind power generation, it exploits fuses and diodes as rated protection module between the power generated and the inverter, and plays an important role in preventing any possible collisions among the power generated.

5. Stand-alone inverter system

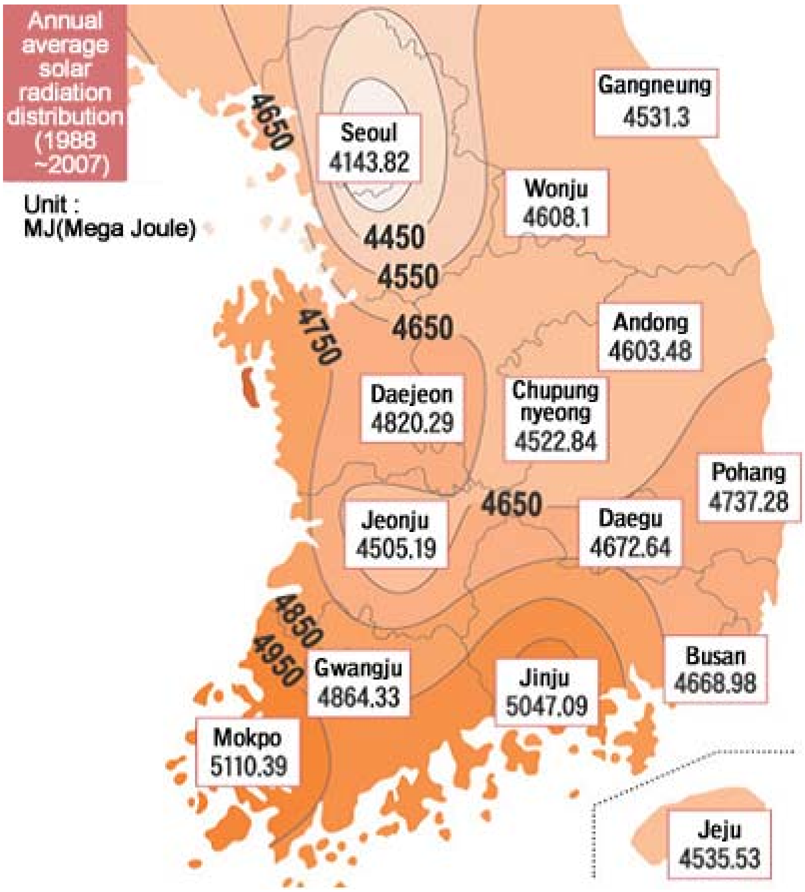


(1) Stand-alone inverter system is not connected with power system of commercial, but it is the generating system used as independent power, so it is mostly used in the undeveloped region where commercial power system cannot be supplied and when independent power is required because of certain circumstance.

(2) Because there are time differences between generating time and time that consumes electricity, most independent systems are equipped with battery, and it saves generated power to battery, and discharge the battery uf necessity to use the power.

(3) It is varied from small size to large size, and small sizes, such as table calculator or clock using solar battery cannot called as the devices that use independent power system. Large size is used for emergency power of mountain cabin, villa, laboratory facility or emergency equipment. Because it is not related to commercial power, it can be operated independently when commercial power is blacked out due to disaster.

6. Solar Energy Data (Annual Average Quantity of Solar Radiation on 1㎡)



Photovoltaic Energy Resource Map

7. Estimation of Power Generation using Solar Energy Data

(1) As 1J=1/3600Wh, 1MJ = 277.78Wh

(2) When estimating the amount of power generated in Jeonju area using the photovoltaic energy resource map,

1) How much is the annual average quantity of solar radiation on 1㎡ in Jeonju area?

- 4505.19MJ = 4505.19×277.78Wh ≒ 1251KWh

2) Calculation method of gross photovoltaic generation(KWh) on the exploitation of 200W module

- Gross PV Generation(KWh)= Inverter Generation Efficiency(%) × Quantity of Solar Radiation on Inclined Plane(Annual Average) × Array Area(㎡) × Solar Cell Efficiency(%) X 0.95(Loss Coefficient)
- Inverter Generation Efficiency = 0.95%
- Quantity of Solar Radiation on Inclined Plane(Annual Average) = 1251KWh
- 200W Array Area = Area of 1 Cell × No. of Cells installed on Module × Module Efficiency = 0.156*0.156*54*1=1.314 ㎡
- Solar Cell Efficiency = 0.14%
- Gross PV Generation (KWh) = 0.95 × 1251KWh × 1.314 × 0.14 × 0.95 = 207.7KWh
- Therefore, a 200W module installed in Jeonju area may, in theory, generate 207.7KWh.

3) What if a 3KW module is employed?

- Annual Gross Generation = 207.7KWh × No. of Modules(16) = 3323.13KWh
- Monthly Average Generation = 3323.13KWh ÷ 12 months = 276.93KWh

(3) When a 3KW module is employed, the result of estimation, applied with the actual energy measurement data, quantity of solar radiation by area, solar cell and inverter efficiency, shows that 276.93KWh shall be generated per year.

(4) The above calculation method, however, shall be applicable only to the dual-axis tracker. When it comes to single-axis or fixed-axis device, the efficiency of each factor must be given respectively. Although it is said that the efficiency of single-axis is 85% and fixed-axis is 70% compared to a dual-axis tracker with 100% efficiency, it is imperative to employ more reliable data.

ex) Where 3KW fixed-axis tracker is used:

Annual Gross Generation: 3323.13KWh × 0.7= 2326.19KWh estimated

Monthly Average Generation: 2326.19 ÷ 12 = 193.85 KWh estimated

(5) Still, these are just theoretical values. It is practically out of the question to calculate the exact amount of power generation, as there exist myriad variables on the spot, i. e. quantity of solar radiation, temperature, wind speed, longitude, latitude, inclination, azimuth, and number of series connections).

8. Selection of Proper Photovoltaic Module

(1) When a DC 60W light bulb is used for 8 hours a day in Jeonju area?

1) How much capacity of photovoltaic device is required (when the solar cell efficiency is 0.14%)?

(2) Firstly, you should compute annual power consumption

Annual Power Consumption(Whr) = Power Consumption(W) × 365 Days × Hours Used

= 60×365×8h =175.2KWhr

(3) Gross PV Generation(KWh) = Inverter Generation Efficiency(%) × Quantity of Solar Radiation on Inclined Plane(Annual Average) × Array Area(m^2) × Solar Cell Efficiency(%) × 0.95(Loss Coefficient)

1) How much is the annual average quantity of solar radiation on 1m^2 in Jeonju area?

- 4505.19MJ = 4505.19 × 277.78Wh ≒ 1251KWh

Therefore, the quantity of solar radiation on inclined plane(annual average) = 1251KWh

2) 200W Array Area = Area of 1 Cell × No. of Cells installed on Module × Module Efficiency

= 0.156*0.156*54*1=1.314 m^2

3) How much is the annual gross generation when a 200W module is employed?

- Gross PV Generation (KWh) = 1251KWh × 1.314 × 0.14 × 0.95 = 218.63KWh

(4) How much is the annual gross generation when a 1W module is employed?

1) Annual Gross Generation of 200W Module = 218.63KWh. What if a 1W module is used?

- Annual Gross Generation of 1W Module = 218.63KWh ÷ 200W = 1.093KWhr

(5) How much capacity of solar cell is required?

1) Solar Cell Capacity = Annual Power Consumption/Annual Gross Generation of 1W Module

= 175.2/1.093 ≒ 160.28W

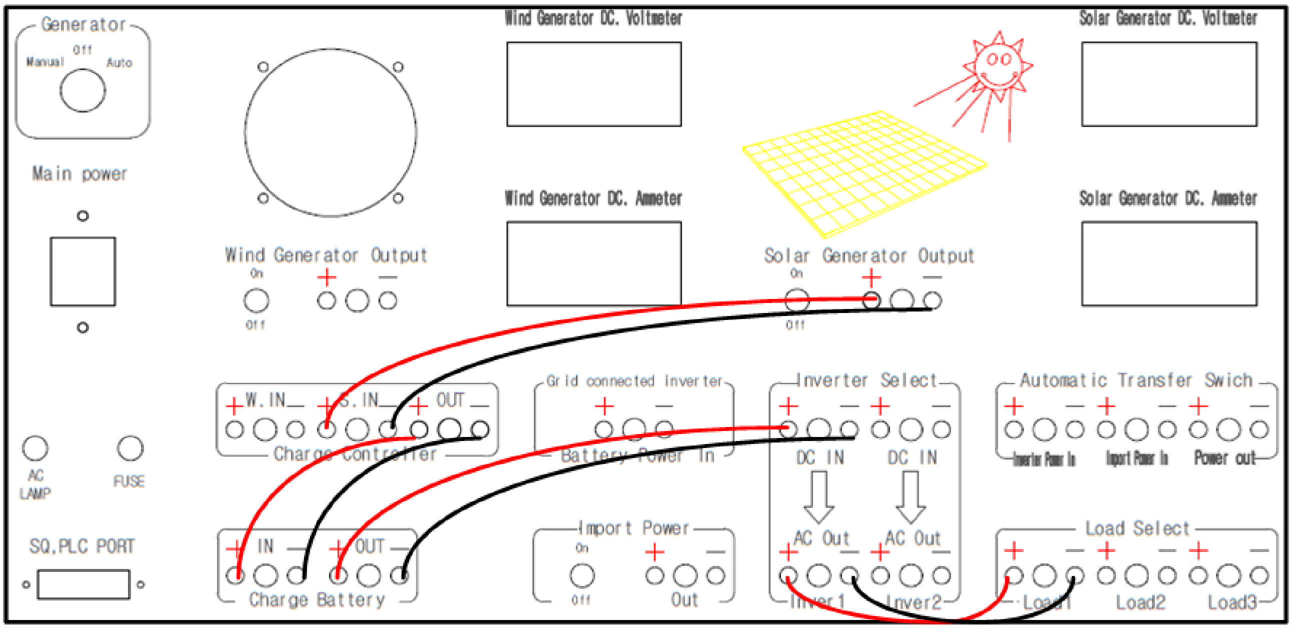
(6) Then, what if a fixed-axis device is employed?

1) 160.28W × 1.3(Fixed-axis Efficiency) = 208.36W or higher

(7) What if a single-axis device is employed?

1) 160W × 1.15(Single-axis Efficiency) = 184.32W or higher

9. Connection diagram



· Requirements

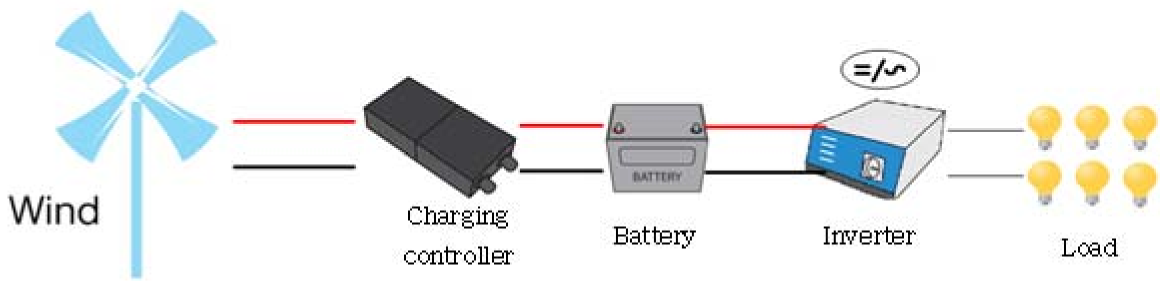
1. Prepare and inspect laboratory apparatus and tools.
2. Using experimental equipment and tools, construct and operate a stand-alone inverter connection.
3. Understand and describe the characteristics of stand-alone inverter.
4. Efficiency of stand-alone inverters can be calculated.
5. Calculate the inverter efficiency according to load capacity change.

Valuation Basis	Evaluation Item		Allot	Obtain	Remarks			
	Item point (80 point)	Prepare the Inverter Action Characteristics	20					
		Battery discharge voltage, current measurement	20					
		Inverter Output Voltage, Current Measurement	20					
		Inverter efficiency calculation	20					
	Work point (10 point)	Work attitude and safety	5					
		Use, arrange, and dispose of materials tools	5					
	Time point (10 point)	Subtract ( ) point in every ( ) minute excess			Item	Work	Time	Total

Experiment name	7. Experimental Study on the Prevention of Charging Controller Overcharge	Class time(hr)
		8
Object	① Understand the circuit from the Department of New and Renewable Energy to the Charging Controller ② Understand the overcharge protection connection between the charging controller and the battery ③ Understand the anti-charge characteristics of the charging controller	

Experiment equipment	Tool & material	Spec of tools	Q`nty
· Hybrid Power Conversion Experiment Equipment (KTE-HB520N)	· Driver · Nipper · Wire stripper · Hook meter	· #2× 6× 175㎜ · 150㎜ · 0.5~6㎟ · 300A 600V	1 1 1 1/Group

Control Circuit



1. Circuit configuration
   (1) Connect the wind generator to the power conversion equipment.
   (2) Connect to the charging controller from the wind generator.
   (3) Connect it to the battery from the charging controller.
   (4) Connect the battery to the inverter.
   (5) Connect with the load from the inverter.

2. Experimental method
   (1) Wind speed is controlled by adjusting the speed of the fan to operate the wind generator.
   (2) Experiment by changing the load capacity while charging the battery.

3. Charging controller

Main function of charging controller is to use maximum capacity of battery through normal charging of battery and extent the battery life, so it is applied to both solar and wind power generator. Function of charging controller is to prevent the reverse direction flow of current and overcharge. Some of them have functions that block the overload and over-discharge or display function that shows charging status and flow of power.

(1) Reverse direction flow prevention function

- If day becomes sunshine less, current may flow reverse from battery to solar panel. At this time, by using blocking diode that connects bipolar elements in series or using mosfet element that has less power loss, it can make that current flows only from solar panel to battery.

(2) Overcharge prevention function:

- What will happen if voltage is supplied from solar panel continuously when battery is charged completely? At this time, as battery voltage will be increased excessively, water will be dissolved to oxygen and hydrogen, and gas will occur. From this process, loss of distillate water will be caused while gas is ignited, so it may cause explosive. As a result, battery will be deteriorated and life cycly will be shorten. To prevent overcharge, block the current if battery voltage reaches to certain level.

(3) Over-discharge prevention function.

- Connect the current again if voltage of battery drops to less than certain voltage. This is called as voltage regulating, and it is the basic function of all charging controller.

A. On.off method

- Some controllers repeat the block or connect current flows to battery completely to control the current flow. This is called as on/off control method.

B. Pwn method

- If battery is charged completely, it will go to second step, in second step, voltage that is about to maintain the battery will be dropped. This is called as trickle charge. It only charges with amounts that water drop falls. Two steps charging control is meaningful in the environment that power usage is too much ot too less, that is, charging/discharging is not stable.

C. Maximum power point tracking (MPPT) method

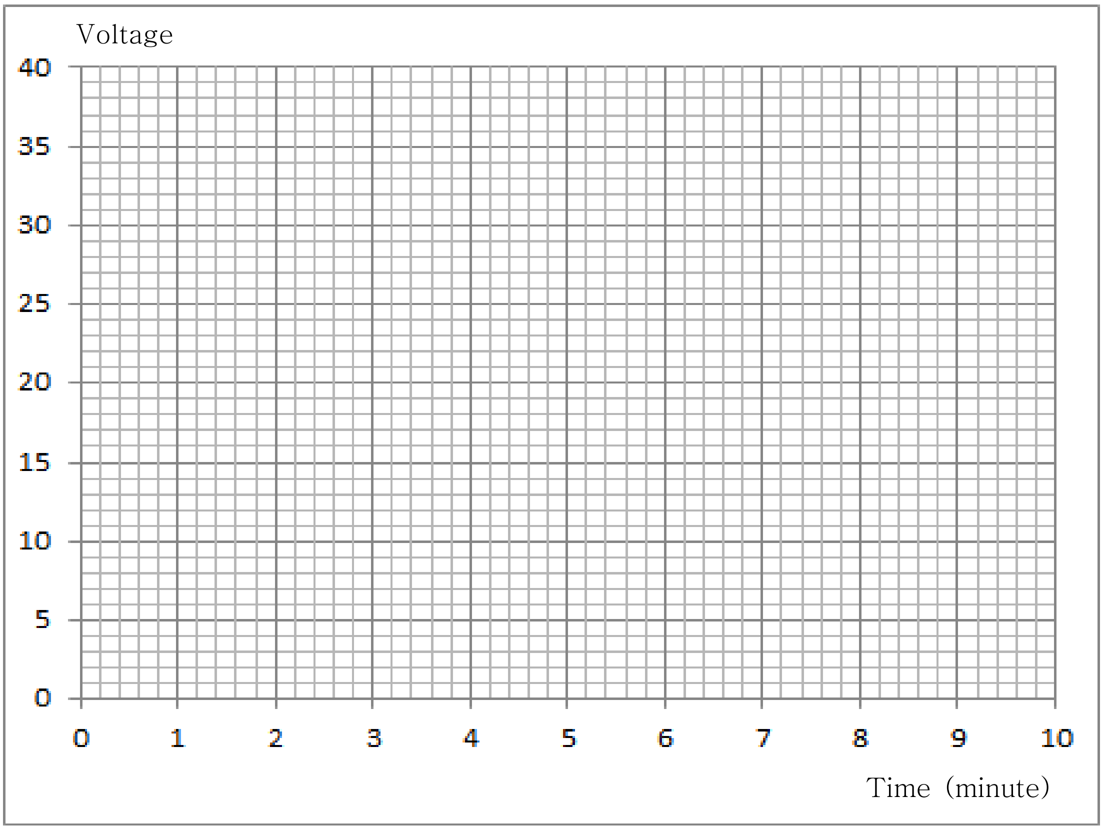
- It is also known as, maximum power point tracking. The most biggest difference with above method is that it matches the voltage of battery with voltage generated in panel to obtain maximum charging efficiency. This is similar principle that matches optimum ratio of engine rotating and wheel rotating numbers using gear transmission. Specially, it can obtain the maximum 30% of charging efficiency increasing effect in winter season than normal pwm method.

4. Experiment for measurement after connecting the wind farm or connecting to a DC supply.

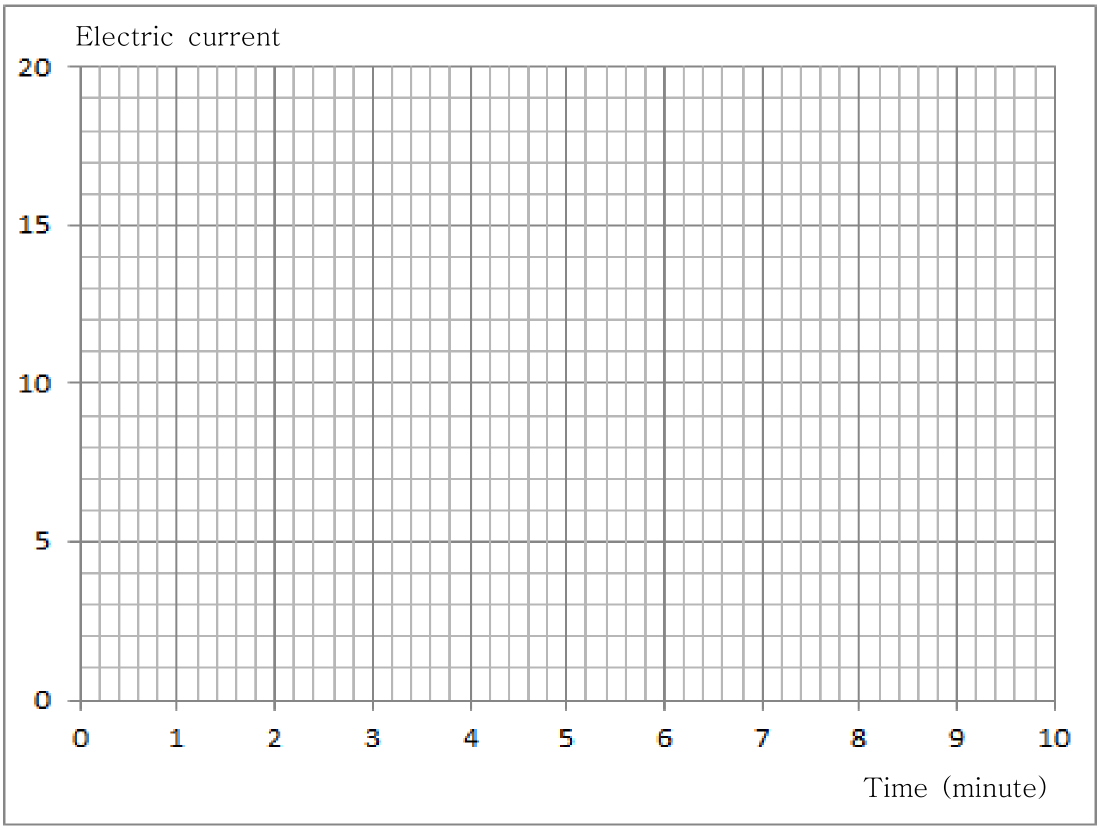
(1) Mark in the table below the measured value of charging voltage V, current I (A), and calculate the charging power, P (W).

time	0	1min	2min	3min	4min	5min	6min	7min	8min	9min	10min
V											
I(A)											
P(W)											

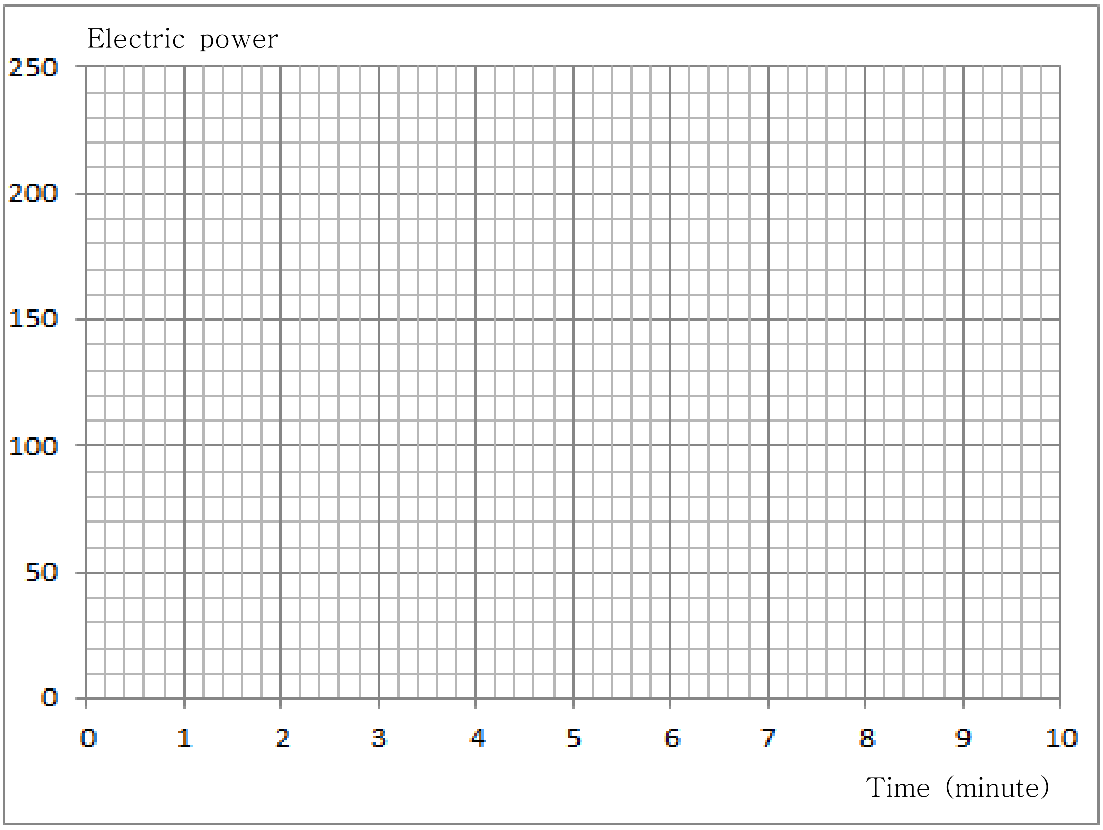
(2) Draw a charging voltage (V) curve.



(3) Draw a charging current (I) curve.



(4) Draw a curve of charging power (W).

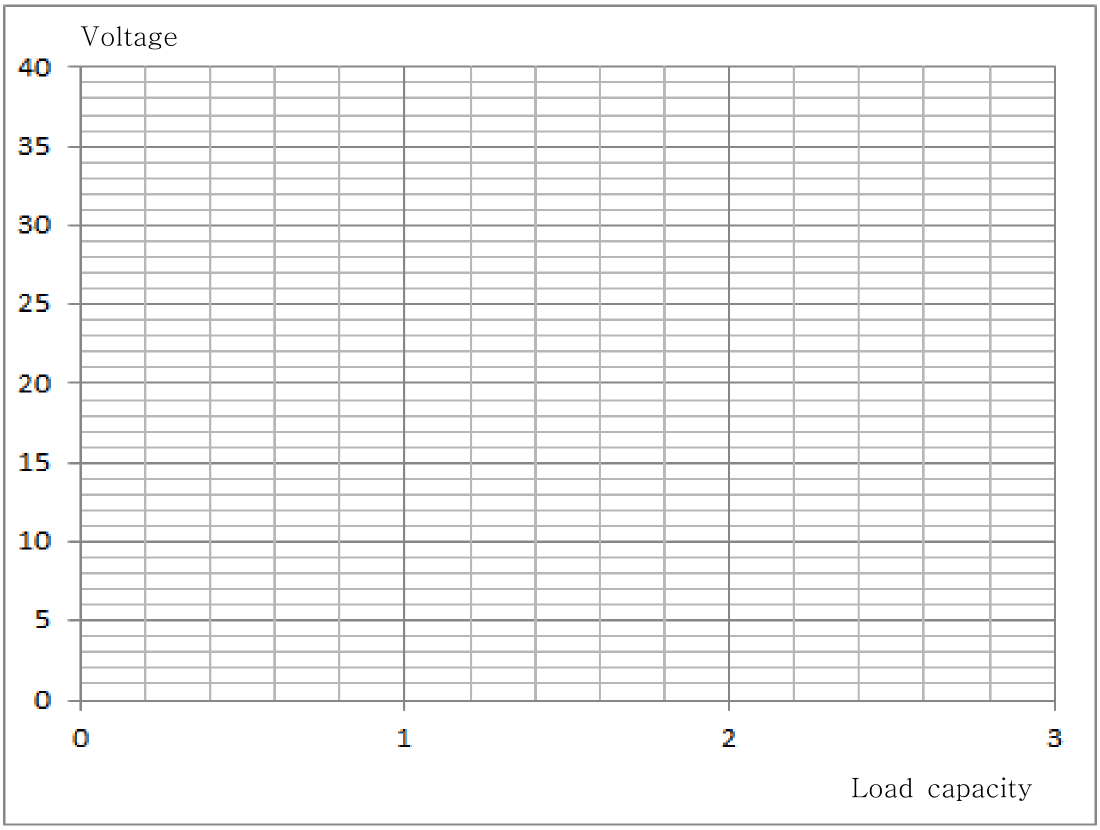


5. Charging measurement experiment with load change after connection of wind generator

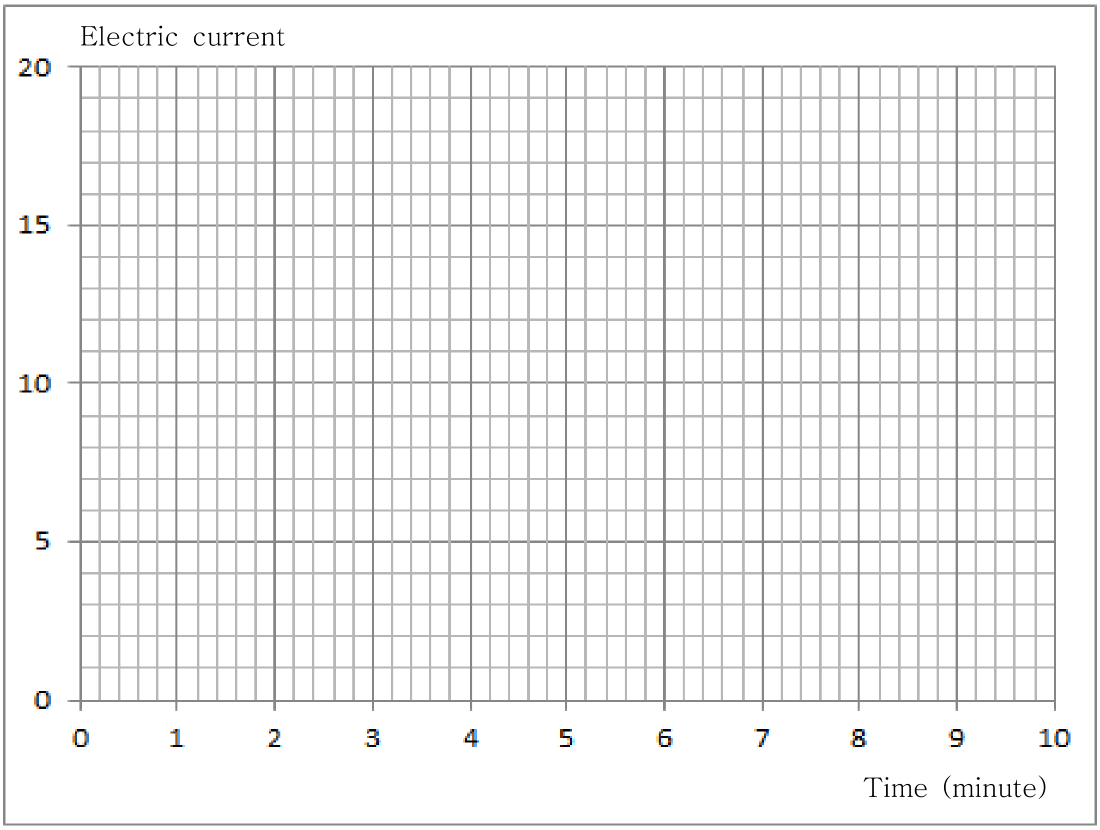
(1) Calculate the charging power (W) by marking the measured value of charging voltage V, current I (A) in the table below.(Load capacity is recorded by viewing the digital wattmeter.)

Load capacity	0			
V				
I(A)				
P(W)				

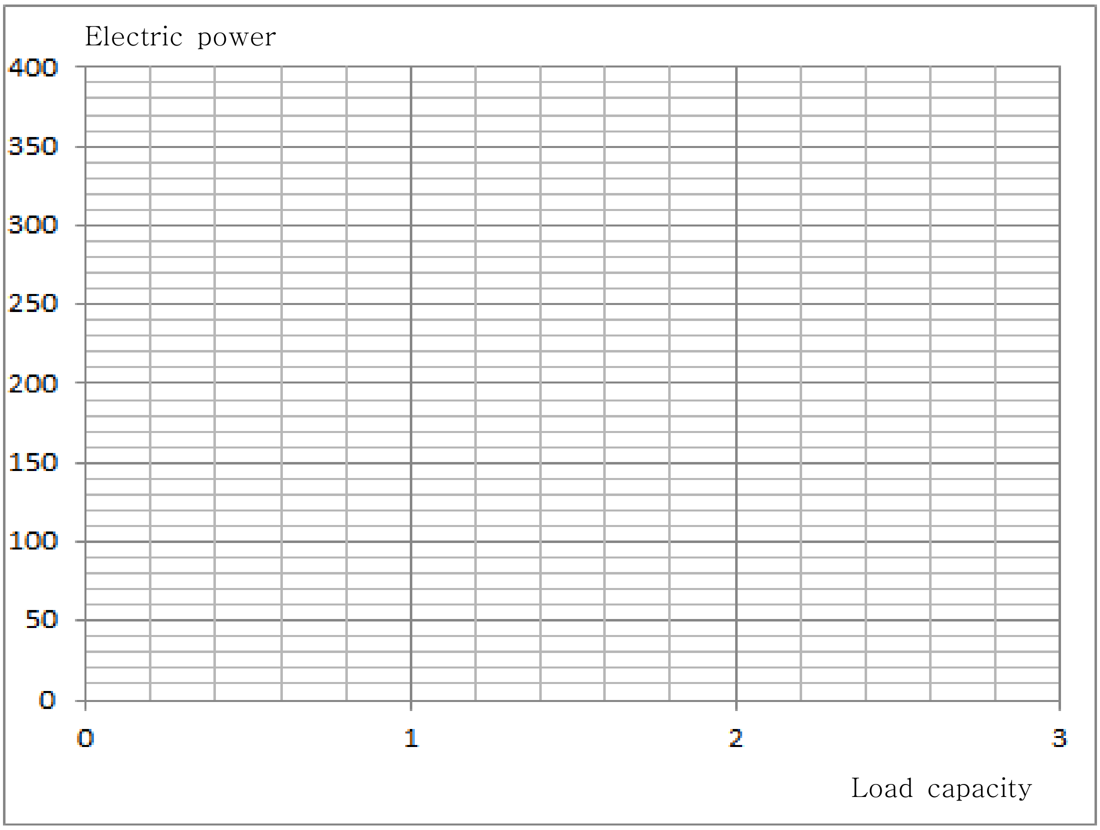
(2) Draw a charging voltage (V) curve.



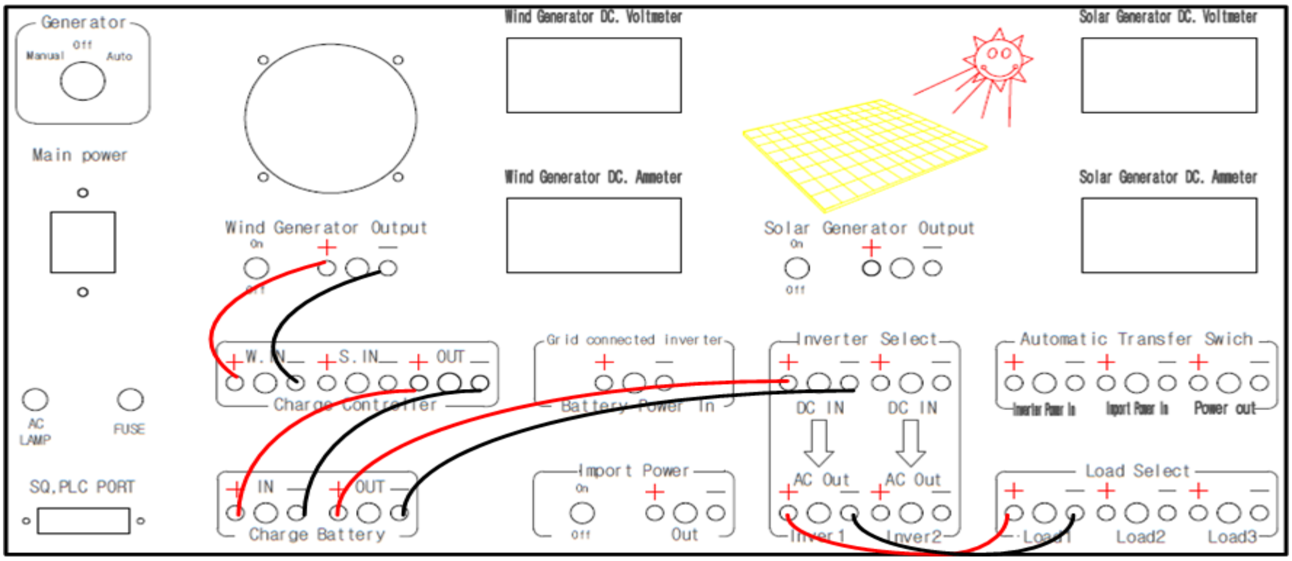
(3) Draw a charging current (I) curve.



(4) Draw a charging power (W) curve.



6. Connection diagram



· Requirements

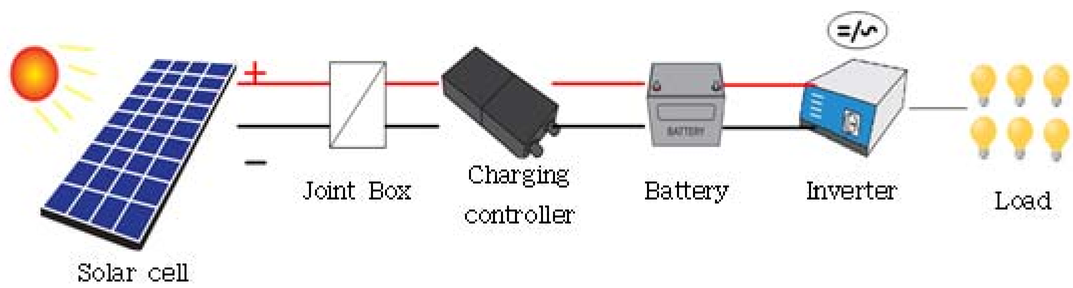
1. Prepare and inspect laboratory apparatus and tools.
2.Use laboratory equipment and tools to construct and operate the charging controller connection.
3.Compliant and explain the overcharging characteristics of the charging controller.
4. Understand and describe the role of the charging controller.
5. Describe the operating characteristics of the charging controller as the load capacity grows.

Valuation Basis	Evaluation Item		Allot	Obtain	Remarks			
	Item point (80 point)	Prepare the Charging Controller Properties Experiment	20					
		Voltage measurement and graphing	20					
		Current measurement and graphing	20					
		Graph construction based on power value calculation	20					
	Work point (10 point)	Work attitude and safety	5					
		Use, arrange, and dispose of materials tools	5					
	Time point (10 point)	Subtract ( ) point in every ( ) minute excess			Item	Work	Time	Total

Experiment name	8. Battery discharge characteristic experiment	Class time(hr)
		8
Object	① Understand the discharge characteristics of the battery ② Draw the voltage and current graphs according to the discharge capacity of the battery	

Experiment equipment	Tool & material	Spec of tools	Q`nty
· Hybrid Power Conversion Experiment Equipment (KTE-HB520N)	· Driver	· #2× 6× 175㎜	1
	· Nipper	· 150㎜	1
	· Wire stripper	· 0.5~6㎟	1
	· Hook meter	· 300A 600V	1/Group

Control Circuit



1) Circuit configuration
   (1) Connect the solar module in series or in parallel to the connection panel.
   (2) Connect the charger from the connection board.
   (3) Connect the battery from the charging controller.
   (4) Connect the battery to the inverter.
   (5) Connect the load from the inverter to the load.
2) Experimental method
   (1) Connect the bar screw to the bottom of the control panel and select the load capacity of each.
   (2) Measure the battery discharge voltage and current according to the load capacity and calculate the power value.

3. Selecting method of battery

(1) Required battery capacity(Ah) = Lb×Dr×1000×(1+(1-Charging and discharging efficiency / 100) / (L × Vb × N × DOD)

Lb : A day power consumption (KWh)

Dr : Number of continuously sunless days

L : Maintenance factor(usually maintenance-free battery using in solar case)

Vb : Voltage of battery

N : Number of batteries

DOD : depth of discharge (%)

(It is called the DOD 65%, if we designed the 65% discharging of storage battery when the last day of sunless days.)

Charging and discharging efficiency: Usually having 65 to 85% efficiency

(2) What is number of sunless days?

It means "number of days that sun does not shine during all day", and for solar ray generation, electricity is not generated when cloudy day with less sunshine or raining day from solar battery module. These days called as number of sunless days, and this should be considered when selecting a battery. Normally calculated from 3 to 7.

(3) Selection of battery (case of light bulb of 60W using 8 hours in a day)

1) A day power consumption (KWh) = 0.06KW×8h = 0.48KWh

2) Number of continuously sunless days = 3

3) Maintenance factor = maintenance-free battery is ignored.

4) The battery voltage = 12V

5) The number of storage batteries = 1EA

6) Depth of discharge = 65% depth of discharge applies

7) Charging and discharging efficiency 80% applies = (1 + (1-80/100) = 1.2

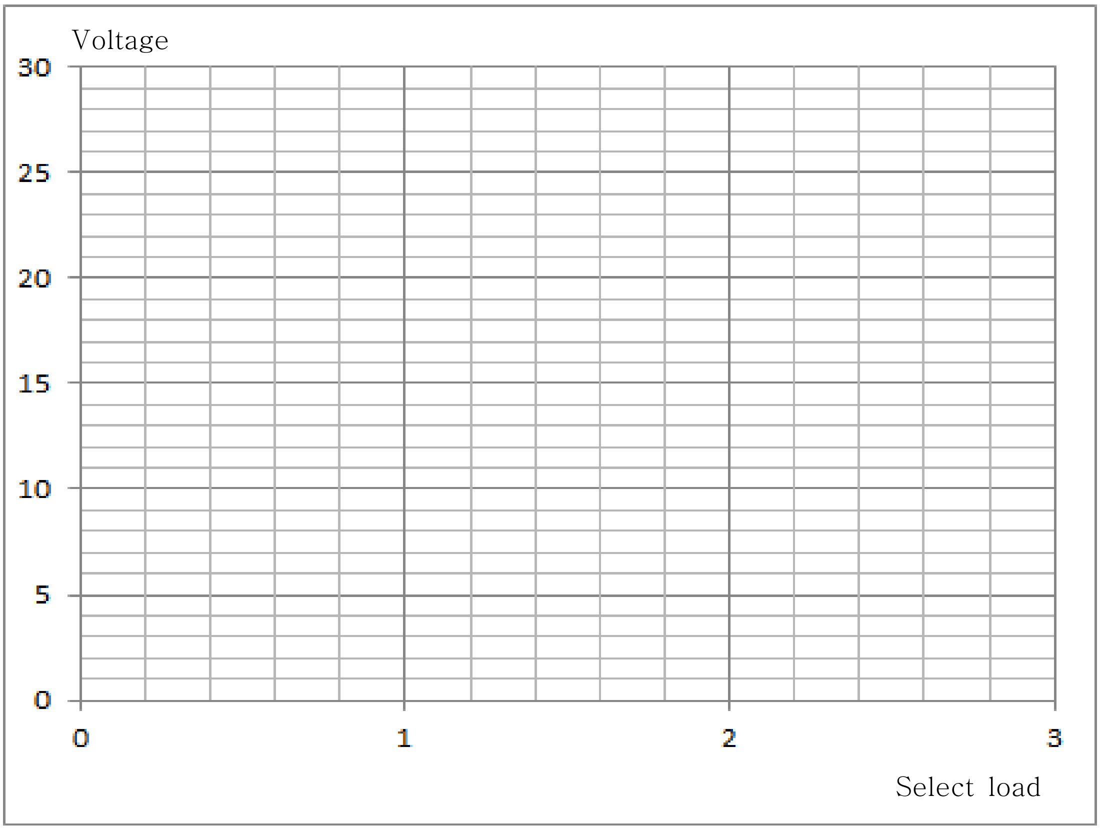
- Battery capacity = 0.48KWh × 3 days × 1000 × 1.2 / (1 × 12V × 1 × 0.65)
  = 221.5AH more

4. Experiment after connecting solar modules or charging them with DC supply

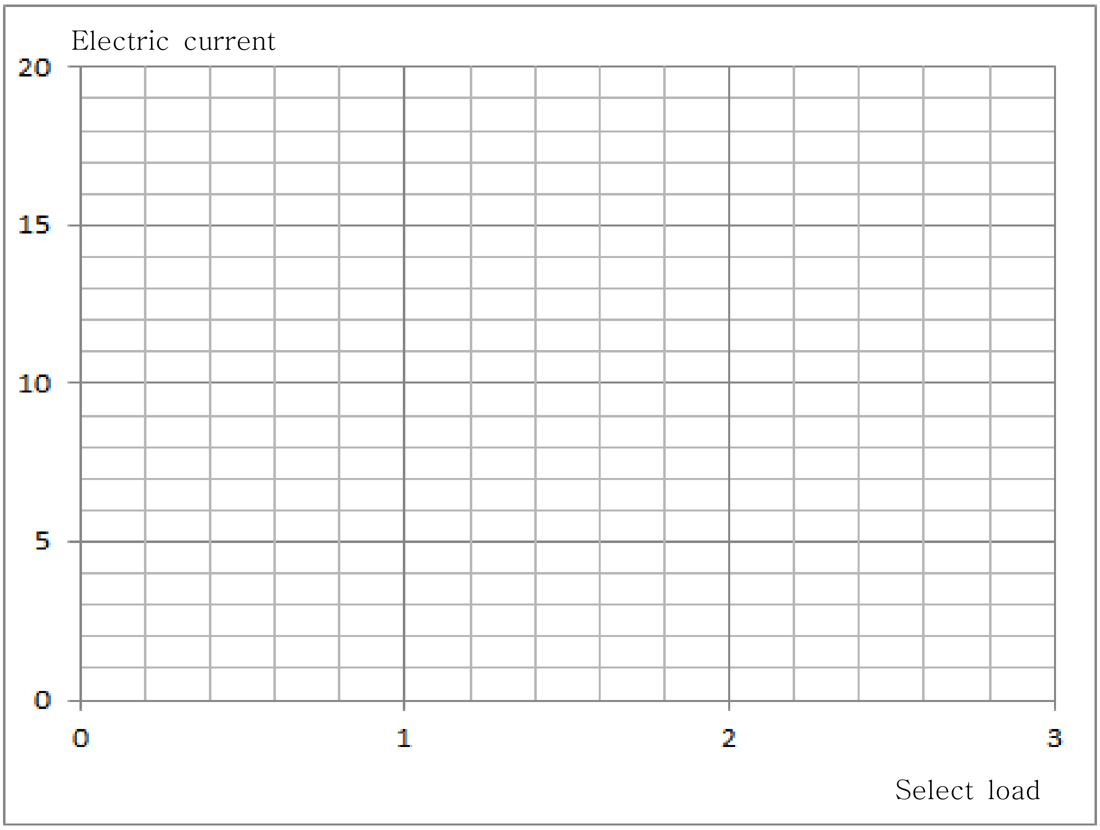
(1) Calculate the power P (W) by marking the measured battery discharge voltage V, current I (A) values in the table below.

Load capacity	0	1 load	2 load	3 load
V				
I(A)				
P(W)				

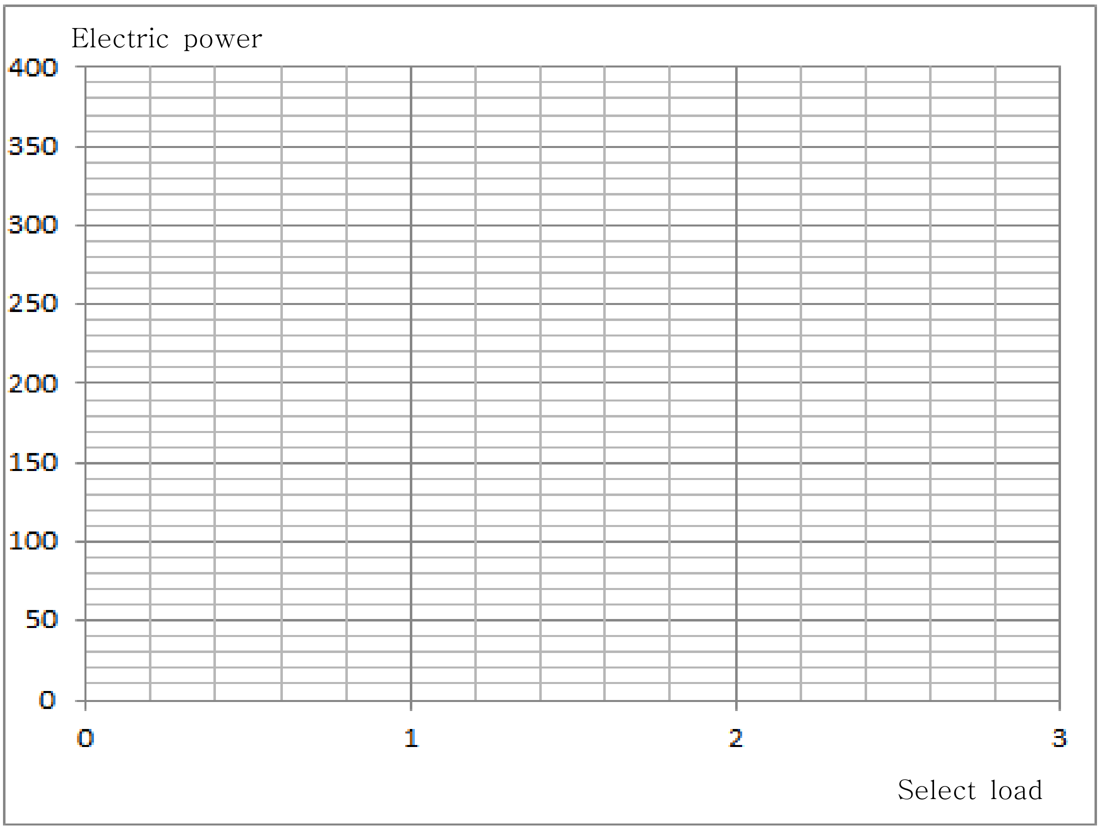
(2) Draw a discharge voltage (V) curve.



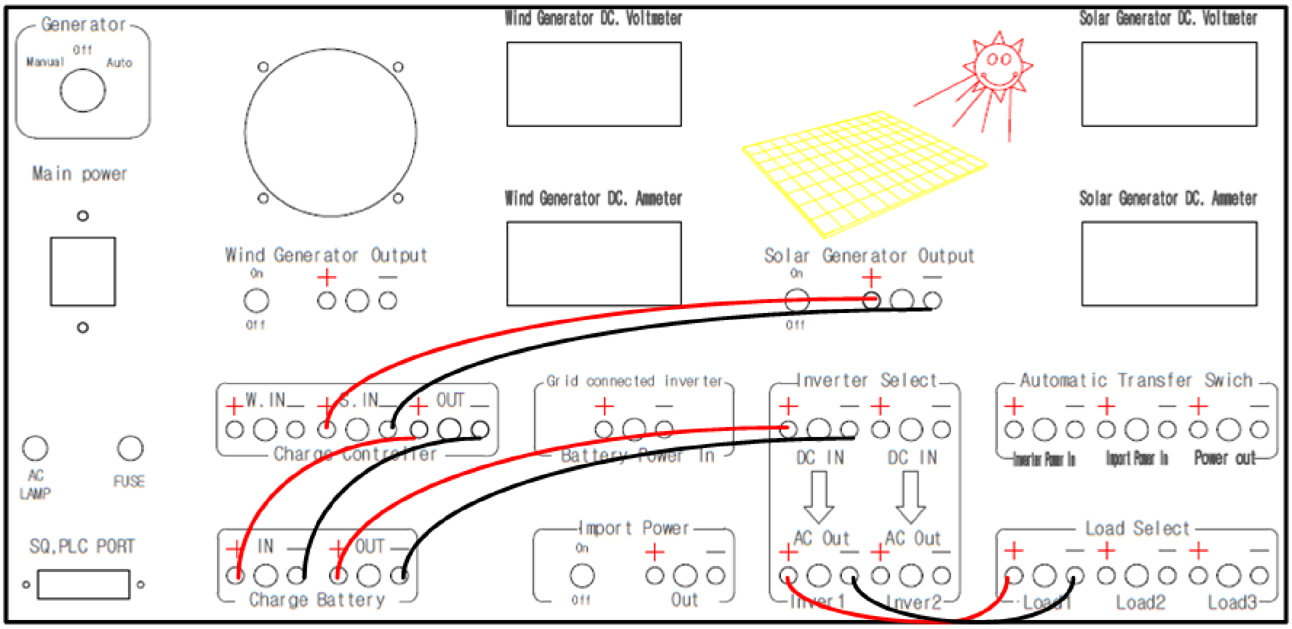
(3) Draw a discharge current (I) curve.



(4) Draw a curve of power (W).



5. Connection diagram



· Requirements

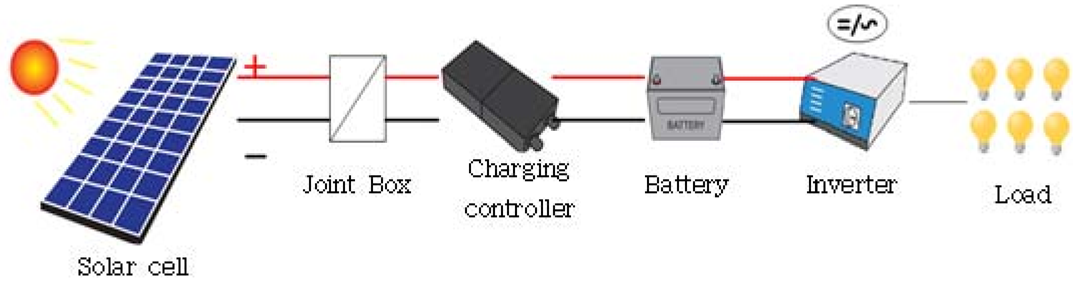
1. Prepare and inspect laboratory apparatus and tools.
2. Using lab equipment and tools, construct and operate a battery connection circuit.
3. Understand and describe the voltage and current characteristics of the battery when it is discharged.
4. Understand and describe the voltage and current characteristics when the battery discharges due to a load capacity change.
5. Calculate the battery discharge capacity according to the load capacity change.

Valuation Basis	Evaluation Item		Allot	Obtain	Remarks			
	Item point (70 point)	Prepare the Battery Discharge Characteristics Experiment	20					
		Voltage measurement and graphing	20					
		Current measurement and graphing	20					
		Graph construction based on power value calculation	20					
	Work point (10 point)	Work attitude and safety	5					
		Use, arrange, and dispose of materials tools	5					
	Time point (20 point)	Subtract ( ) point in every ( ) minute excess			Item	Work	Time	Total

Experiment name	9. An Experiment to Measure the End-of-Rate Voltage by the Battery Discharge Experiment	Class time(hr)
		8
Object	① Understand the discharge characteristics of a battery ② Construct a voltage and current graph based on the discharge capacity of the battery ③ Measure the final voltage when the battery is completely discharged to predict the actual usable battery capacity	

Experiment equipment	Tool & material	Spec of tools	Q`nty
· Hybrid Power Conversion Experiment Equipment (KTE-HB520N)	· Driver · Nipper · Wire stripper · Hook meter	· #2× 6× 175㎜ · 150㎜ · 0.5~6㎟ · 300A 600V	1 1 1 1/Group

Control Circuit



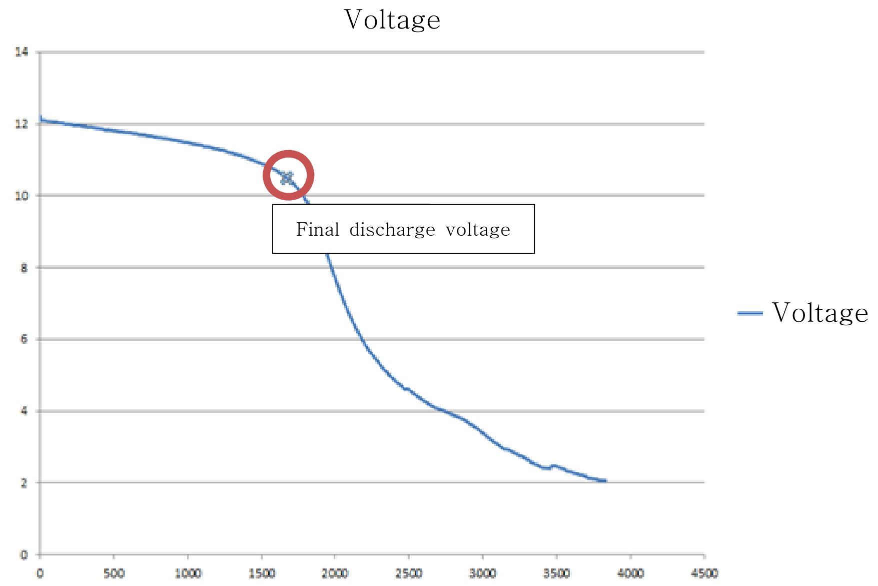
1) Circuit configuration
   (1) Connect the solar module in series or in parallel to the connection panel.
   (2) Connect the charger from the connection board.
   (3) Connect the battery from the charging controller.
   (4) Connect the battery to the inverter.
   (5) Connect the load from the inverter to the load.
2) Experimental method
   (1) Connect the bar screw to the bottom of the control panel and select the load capacity of each.
   (2) Measure the battery discharge voltage and current according to the load capacity and calculate the power value.

3. Connect the Photovoltaic Module or connect the battery to a DC supply and conduct an experiment by connecting the load to the discharge.

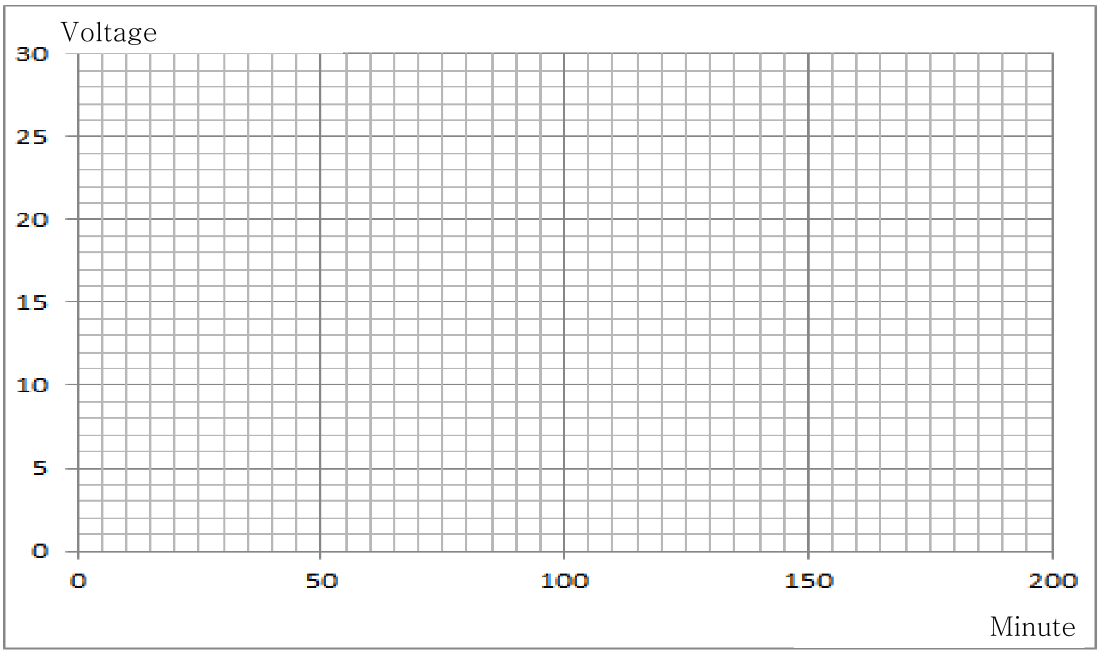
(1) Mark in the following table the measured battery discharge voltage, V, and current drain, I, and calculate the power (W).

Time (min)	V	I(A)	P(W)
0			
5			
10			
15			
20			
25			
30			
35			
40			
45			
50			
55			
60			
65			
70			
75			
80			
85			
90			
95			
100			
105			
110			
115			
120			
125			
130			
135			
140			
145			
150			
155			
160			
165			
170			
175			
180			

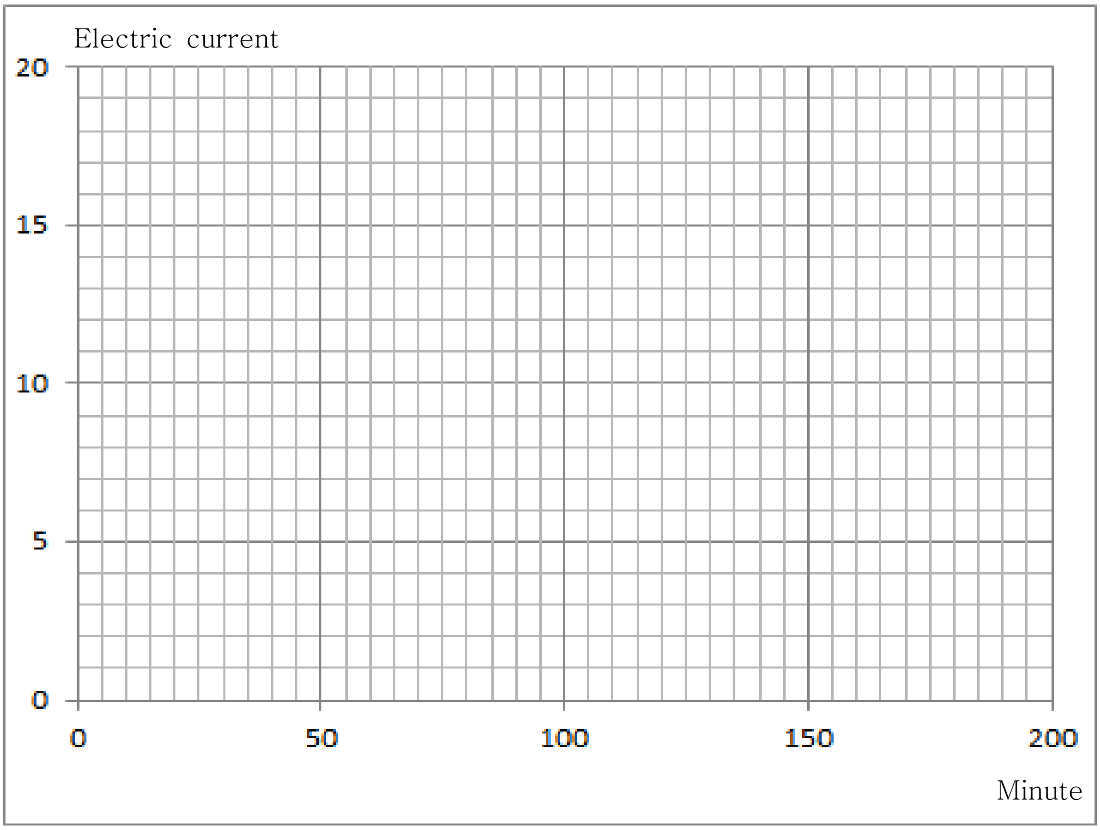
(2) If the battery is used, do not discharge the terminal voltage until it reaches zero. If the voltage drops to a certain limit, discharge is stopped. The voltage at this point is referred to as the discharge termination voltage. The value varies slightly depending on the type of electricity or its purpose, but is usually set to about 90 % of normal voltage. Secondary cells (rechargeable batteries) extend the life of the cell by this method of use. Figure shows the discharge characteristics of the battery.



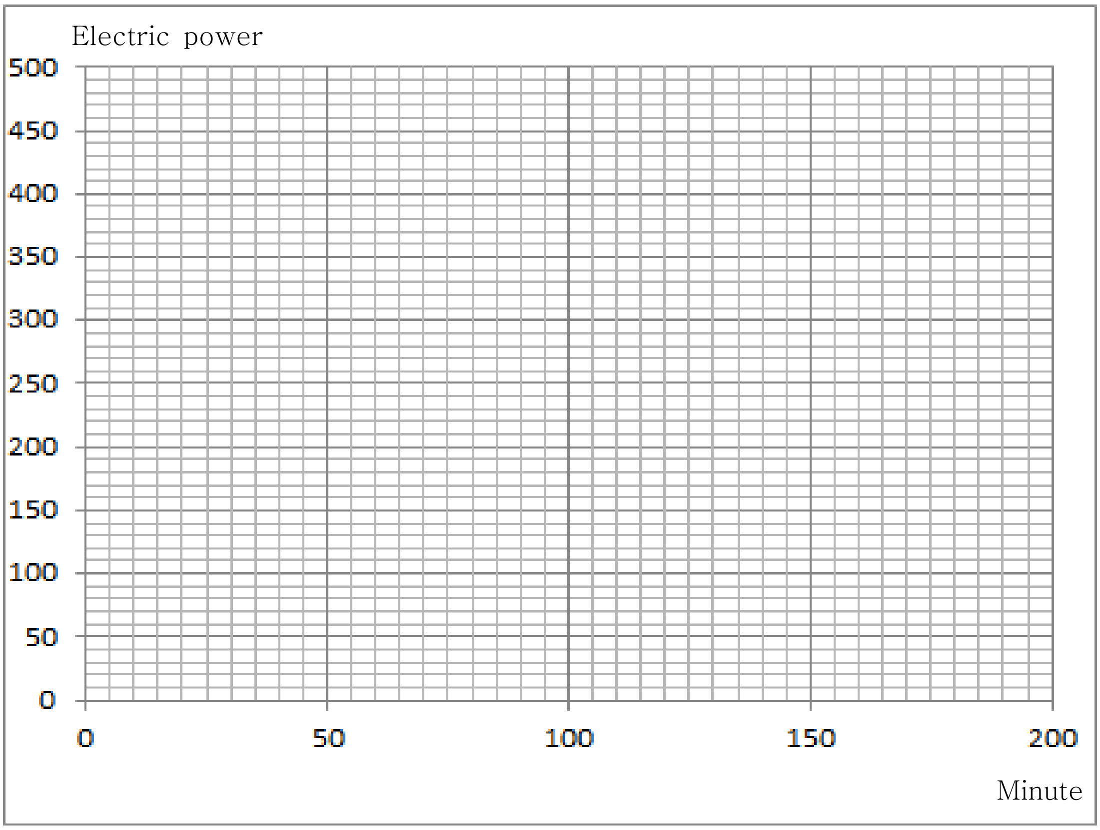
(3) Draw a discharge voltage (V) curve and indicate the final voltage point.



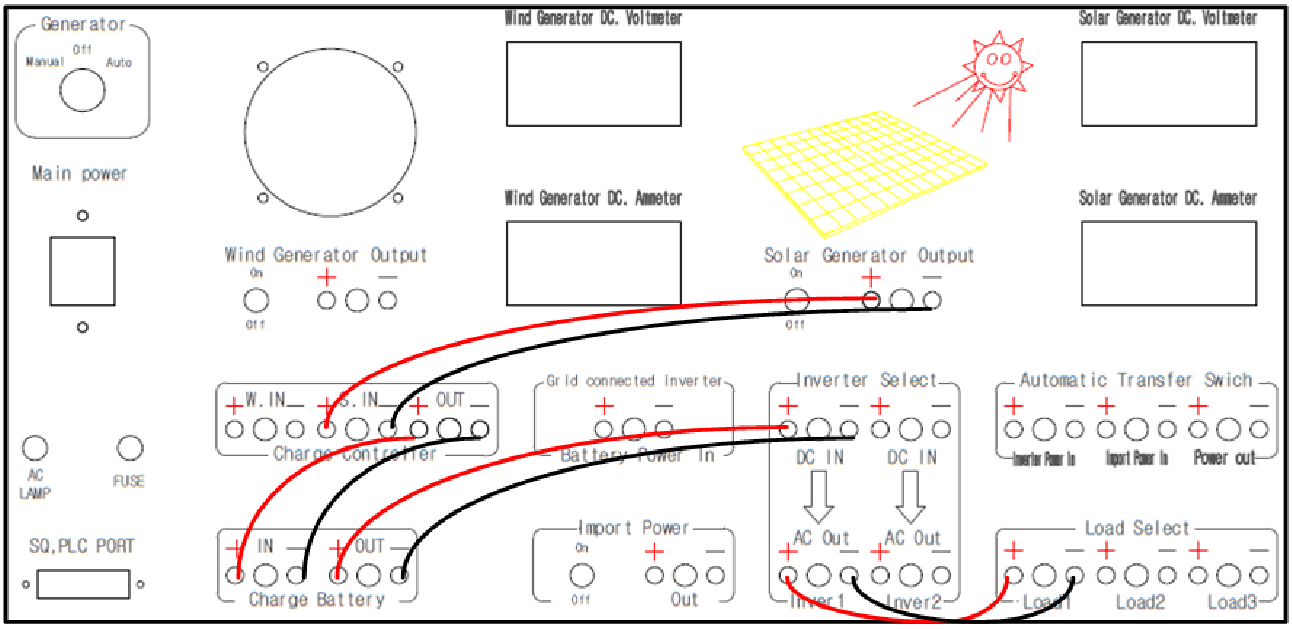
(4) Draw a discharge current (I) curve.



(5) Draw a discharge power (W) curve.



4. Connection diagram



· Requirements

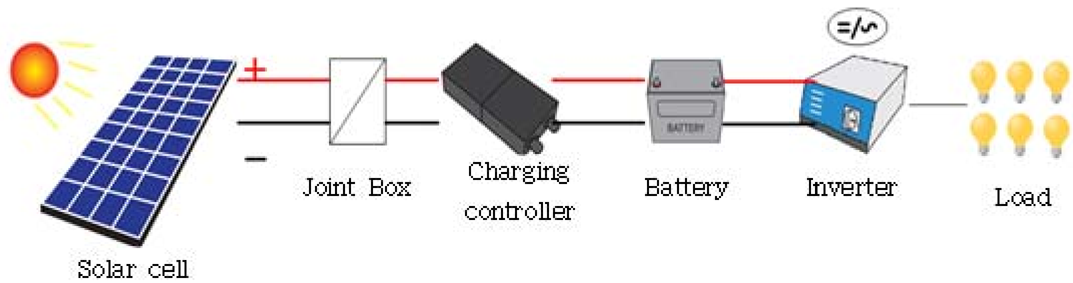
1. Prepare and inspect laboratory apparatus and tools.
2. Using lab equipment and tools, construct and operate a battery connection circuit.
3. Understand and describe the discharge characteristics of the battery.
4. Measure the final voltage of the battery and describe the final voltage.
5. Describe problems when overpressing the battery.

Valuation Basis	Evaluation Item		Allot	Obtain	Remarks			
	Item point (80 point)	Prepare the Battery Discharge Characteristics Experiment	20					
		Voltage measurement and graphing	20					
		Current measurement and graphing	20					
		Graph construction based on power value calculation	20					
	Work point (10 point)	Work attitude and safety	5					
		Use, arrange, and dispose of materials tools	5					
	Time point (10 point)	Subtract ( ) point in every ( ) minute excess			Item	Work	Time	Total

Experiment name	10. Experiment to predict battery state of charge and discharge (SOC) as a result of battery drain	Class time(hr)
		8
Object	① Understand the discharge characteristics of a battery ② Construct a voltage and current graph based on the state of discharge from the b attery ③ Estimate the state of charge and discharge (SOC) using the voltage value at the t ime of battery discharge	

Experiment equipment	Tool & material	Spec of tools	Q`nty
· Hybrid Power Conversion Experiment Equipment (KTE-HB520N)	· Driver · Nipper · Wire stripper · Hook meter	· #2× 6× 175㎜ · 150㎜ · 0.5~6㎟ · 300A 600V	1 1 1 1/Group

Control Circuit



1) Circuit configuration
   (1) Connect the solar module in series or in parallel to the connection panel.
   (2) Connect the charger from the connection board.
   (3) Connect the battery from the charging controller.
   (4) Connect the battery to the inverter.
   (5) Connect the load from the inverter to the load.
2) Experimental method
   (1) Connect the bar screw to the bottom of the control panel and select the load capacity of each.
   (2) Measure the battery discharge voltage and current according to the load capacity and calculate the power value.`

3. An experiment to connect the solar module or the DC supply to fully charge the battery and connect the load to conduct a discharge experiment

(1) Drain the battery to locate the final voltage and convert it into a percentage from the initial voltage value to the final voltage.

E.g.) If the initial battery voltage value is V1 when connected to a load, and the final voltage found is V2, calculate the value at V1 % and calculate the value from V2 to V2 as 0 %.

- Formula

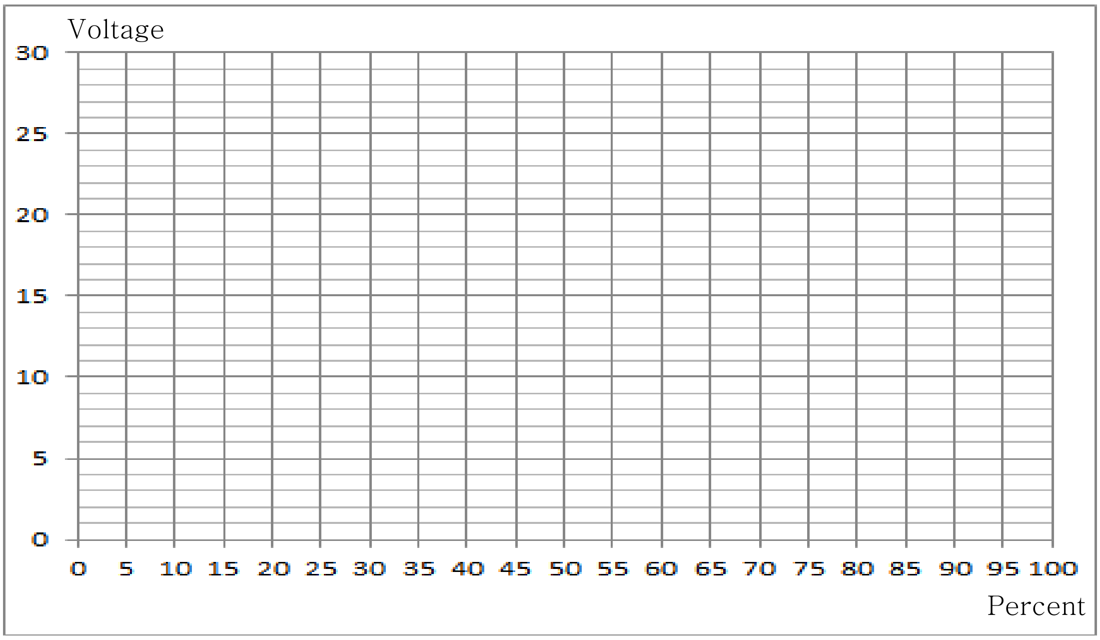
1) $V1-[(V1-V2)\div100]\times(100\%-N\%) = V_n$, N=Percentage value,

V_n= Converted voltage value

2) Charge state (SOC) value from formula 1 = $N(\%)=\dfrac{(V_n-V2)}{(V1-V2)}\times100\%$

Percentage(%)	Formula	V
100	V1	
95	$V1-[(V1-V2)\div100]\times(100-95)$	
90	$V1-[(V1-V2)\div100]\times(100-90)$	
85	$V1-[(V1-V2)\div100]\times(100-85)$	
80	$V1-[(V1-V2)\div100]\times(100-80)$	
75	$V1-[(V1-V2)\div100]\times(100-75)$	
70	$V1-[(V1-V2)\div100]\times(100-70)$	
65	$V1-[(V1-V2)\div100]\times(100-65)$	
60	$V1-[(V1-V2)\div100]\times(100-60)$	
55	$V1-[(V1-V2)\div100]\times(100-55)$	
50	$V1-[(V1-V2)\div100]\times(100-50)$	
45	$V1-[(V1-V2)\div100]\times(100-45)$	
40	$V1-[(V1-V2)\div100]\times(100-40)$	
35	$V1-[(V1-V2)\div100]\times(100-35)$	
30	$V1-[(V1-V2)\div100]\times(100-30)$	
25	$V1-[(V1-V2)\div100]\times(100-25)$	
20	$V1-[(V1-V2)\div100]\times(100-20)$	
15	$V1-[(V1-V2)\div100]\times(100-15)$	
10	$V1-[(V1-V2)\div100]\times(100-10)$	
5	$V1-[(V1-V2)\div100]\times(100-5)$	
0	V2	

(2) Calculate and record the voltage value calculated as a percentage and anticipate the congestion and discharge conditions according to the battery discharge voltage.



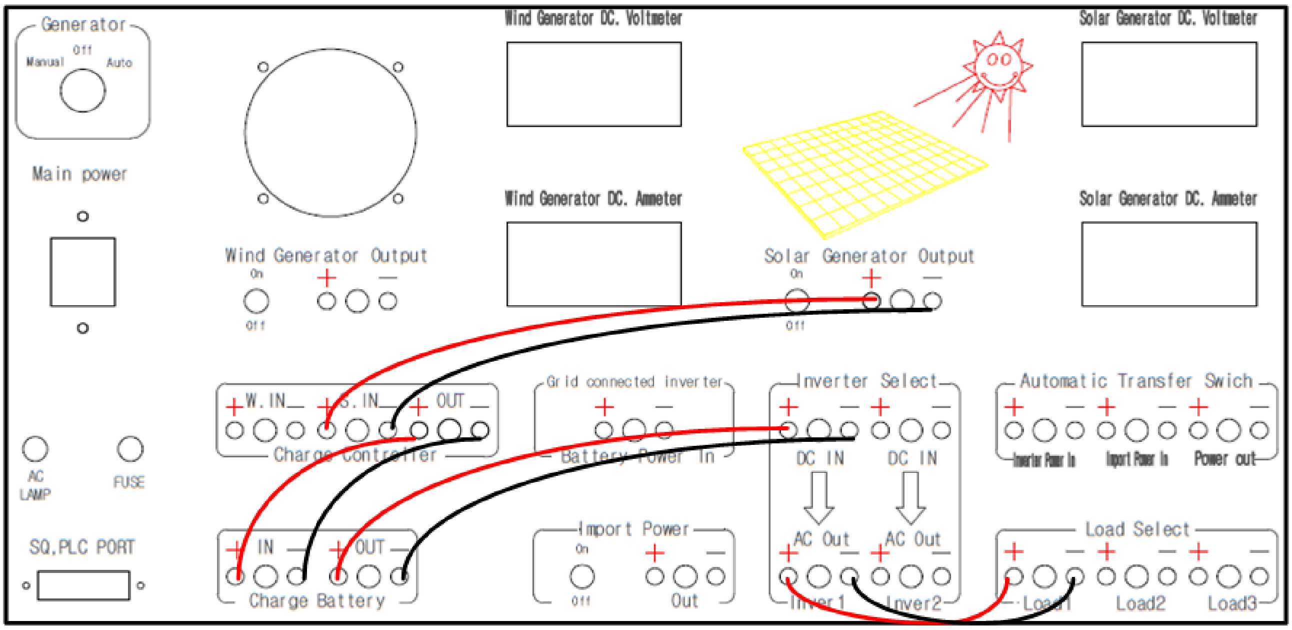
(3) Estimates of battery state of charge and discharge (SOC) values include measuring and estimating the specific gravity of the electrolyte or using Ah Counting. First, measuring and estimating electrolyte specific gravity is based on measuring electrolyte specific gravity and the specific gravity of the fully charged and discharged state, so you can estimate the charge and discharge time based on the estimate of the SOC charging and return current levels. As such, it is very difficult to measure the correct state of charge and discharge of a battery with variables such as electrolyte concentration, charge/discharge cycles, rated capacity, and service temperature. Therefore, for the typical method of expressing the state of charge and discharge, the method of expressing the state of charge and discharge with the voltage values is used.

(4) Required battery capacity (Ah) = Lb × Dr × 1000 × (1 + (1 + charge, discharge efficiency / 100) / (L × Vblock × N × DMS)

Lb : Daily power consumed (KWh), Dr:conduction Day, L:Repair Rate (usually free battery for solar)

Vblock : Battery Voltage, N : Number of batteries, DOD:discharge depth (%), Charging and discharge efficiency : Normally (65 % to 85 %), discharge of the battery capacity shall be made to 65 % on the last day of support days.)

(4) Connection diagram



· Requirements

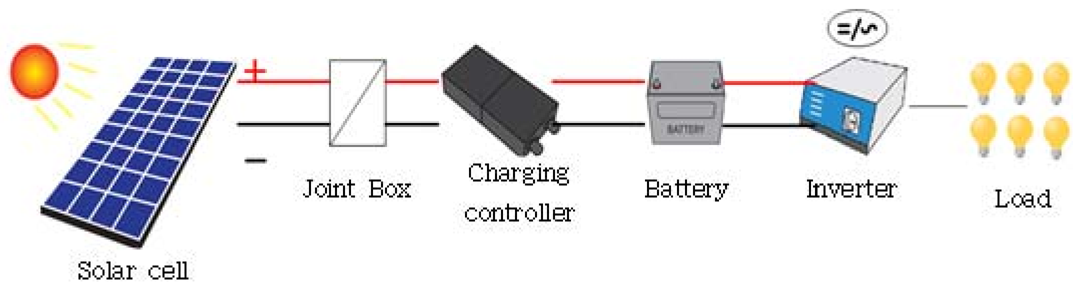
1. Prepare and inspect laboratory apparatus and tools.
2. Using experimental equipment and tools, construct and operate a battery circuit to connect the battery to the battery.
3. Understand and describe the final voltage when the battery is discharged.
4. Understand and describe the battery compartment discharge (SOS) value estimation.
5. Before and after an experiment, the power-meter can be checked to measure the consumption of power to the battery's final voltage and select the actual discharge depth (%). It also describes how to select the capacity of the battery.

<table>
<tr><td rowspan="8">Valuation Basis</td><td colspan="2">Evaluation Item</td><td>Allot</td><td>Obtain</td><td colspan="4">Remarks</td></tr>
<tr><td rowspan="4">Item point (70 point)</td><td>Prepare battery SOC estimation experiment</td><td>20</td><td></td><td colspan="4" rowspan="6"></td></tr>
<tr><td>Calculate the voltage value converted as a percentage</td><td>20</td><td></td></tr>
<tr><td>Voltage value calculation and graphing</td><td>20</td><td></td></tr>
<tr><td>Calculate battery capacity selection</td><td>20</td><td></td></tr>
<tr><td rowspan="2">Work point (10 point)</td><td>Work attitude and safety</td><td>5</td><td></td></tr>
<tr><td>Use, arrange, and dispose of materials tools</td><td>5</td><td></td></tr>
<tr><td>Time point (20 point)</td><td colspan="3">Subtract ( ) point in every ( ) minute excess</td><td>Item</td><td>Work</td><td>Time</td><td>Total</td></tr>
</table>

Experiment name	11. Battery Residual Life Prediction Experiment Based on Battery Capacity Calculator	Class time(hr)
		8
Object	① The discharge capacity of a battery can be calculated. ② The remaining battery life can be predicted according to the discharge capacity of the battery.	

Experiment equipment	Tool & material	Spec of tools	Q`nty
· Hybrid Power Conversion Experiment Equipment (KTE-HB520N)	· Driver	· #2× 6× 175㎜	1
	· Nipper	· 150㎜	1
	· Wire stripper	· 0.5~6㎟	1
	· Hook meter	· 300A 600V	1/Group

Control Circuit



1) Circuit configuration

(1) Connect the solar module in series or in parallel to the connection panel.

(2) Connect the charger from the connection board.

(3) Connect the battery from the charging controller.

(4) Connect the battery to the inverter.

(5) Connect the load from the inverter to the load.

2) Experimental method

(1) Connect the bar screw to the bottom of the control panel and select the load capacity of each.

(2) Measure the battery discharge voltage and current according to the load capacity and calculate the power value.

3. An experiment to connect the solar module or the DC supply to fully charge the battery and connect the load to conduct a discharge experiment

(1) Drain the battery to locate the final voltage and convert it into a percentage from the initial voltage value to the final voltage.

E.g.) If the initial battery voltage value is V1 when connected to a load, and the final voltage found is V2, calculate the value at V1 % and calculate the value from V2 to V2 as 0 %.

- Formula

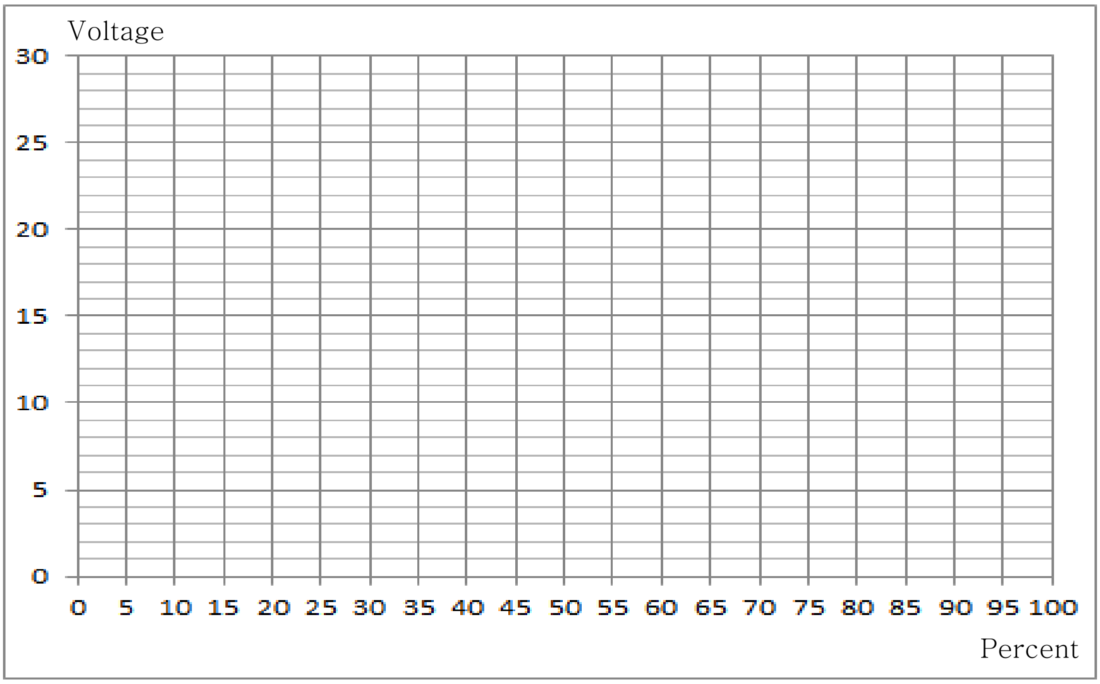
1) $V1-[(V1-V2)\div 100]\times(100\%-N\%) = V_n$, N=Percentage value,

V_n= Converted voltage value

2) Charge, discharge (SOC) value from Formula 1 = $N(\%)=\frac{(V_n-V2)}{(V1-V2)}\times 100\%$

Percentage(%)	계산식	V
100	V1	
95	$V1-[(V1-V2)\div 100]\times(100-95)$	
90	$V1-[(V1-V2)\div 100]\times(100-90)$	
85	$V1-[(V1-V2)\div 100]\times(100-85)$	
80	$V1-[(V1-V2)\div 100]\times(100-80)$	
75	$V1-[(V1-V2)\div 100]\times(100-75)$	
70	$V1-[(V1-V2)\div 100]\times(100-70)$	
65	$V1-[(V1-V2)\div 100]\times(100-65)$	
60	$V1-[(V1-V2)\div 100]\times(100-60)$	
55	$V1-[(V1-V2)\div 100]\times(100-55)$	
50	$V1-[(V1-V2)\div 100]\times(100-50)$	
45	$V1-[(V1-V2)\div 100]\times(100-45)$	
40	$V1-[(V1-V2)\div 100]\times(100-40)$	
35	$V1-[(V1-V2)\div 100]\times(100-35)$	
30	$V1-[(V1-V2)\div 100]\times(100-30)$	
25	$V1-[(V1-V2)\div 100]\times(100-25)$	
20	$V1-[(V1-V2)\div 100]\times(100-20)$	
15	$V1-[(V1-V2)\div 100]\times(100-15)$	
10	$V1-[(V1-V2)\div 100]\times(100-10)$	
5	$V1-[(V1-V2)\div 100]\times(100-5)$	
0	V2	

(2) Calculate and record the voltage value calculated as a percentage and anticipate the state of charge and discharge based on the battery discharge voltage.



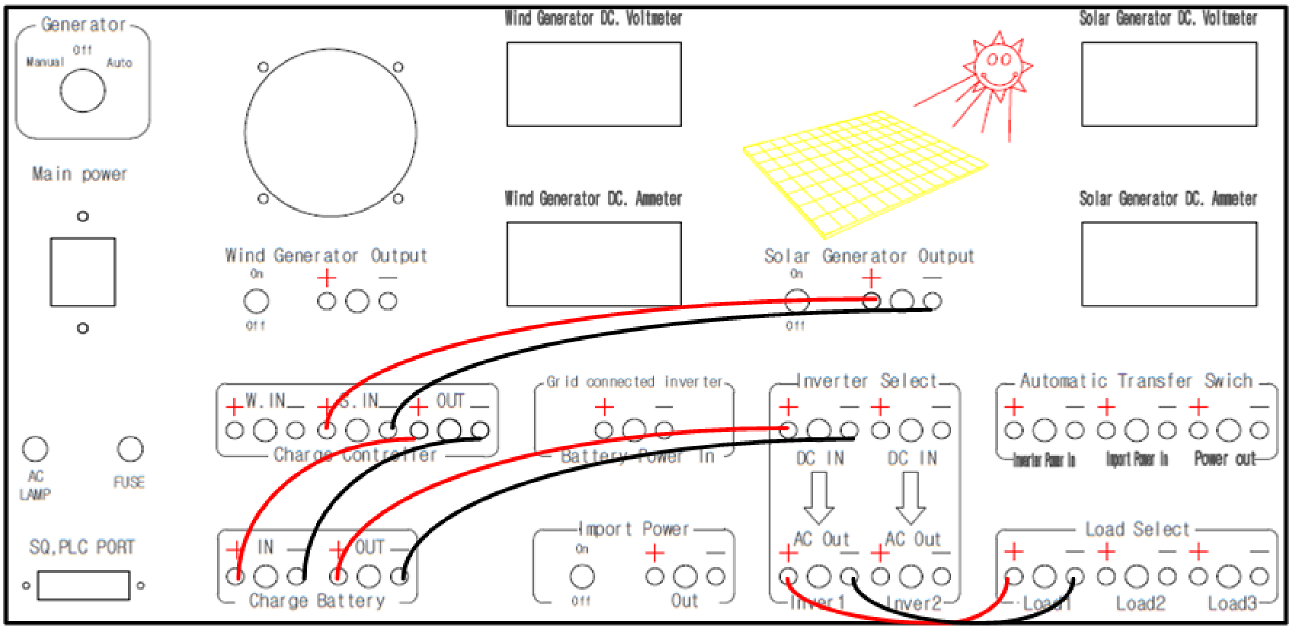
(3) Estimates of battery state of charge and discharge (SOC) values include measuring and estimating the specific gravity of the electrolyte or using Ah Counting. First, measuring and estimating electrolyte specific gravity is based on measuring electrolyte specific gravity and the specific gravity of the fully charged and discharged state, so you can estimate the battery's charge and discharge rate by measuring the battery's charge and charge rate based on the actual charge time. As such, it is very difficult to measure the correct state of charge and discharge of a battery with variables such as electrolyte concentration, charge/discharge cycles, rated capacity, and service temperature. Therefore, for the typical method of expressing the state of charge and discharge, the method of expressing the state of charge and discharge with the voltage values is used.

(4) Required battery capacity (Ah) = Lb × Dr × 1000 × (1 + (1 + charge, discharge efficiency / 100) / (L × Vblock × N × DMS)

Lb : Daily power consumed (KWh), Dr:conduction Day, L:Repair Rate (usually free battery for solar)

Vblock : Battery Voltage, N : Number of batteries, DOD:discharge depth (%), Charging and discharge efficiency : Normally (65 % to 85 %), discharge of the battery capacity shall be made to 65 % on the last day of support days.)

(4) Connection diagram



· Requirements

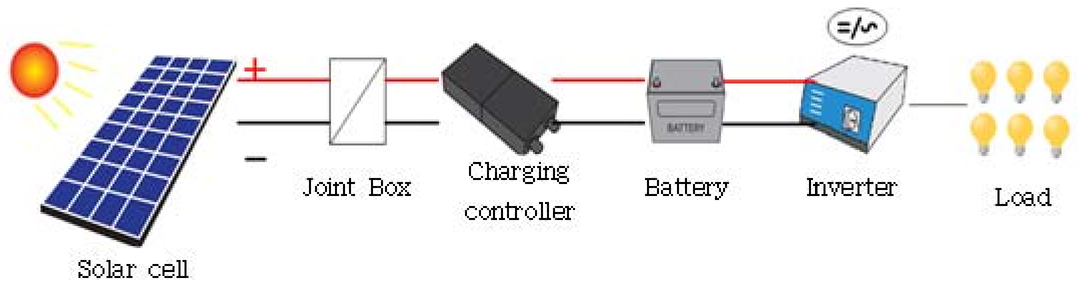
1. Prepare and inspect laboratory apparatus and tools.
2. Using experimental equipment and tools, construct and operate a battery circuit to connect the battery to the battery.
3. Understand and describe the final voltage when the battery is discharged.
4. Understand and describe the battery compartment discharge (SOS) value estimation.
5. Before and after an experiment, the power-meter can be checked to measure the consumption of power to the battery's final voltage and select the actual discharge depth (%). It also describes how to select the capacity of the battery.

<table>
<tr><td rowspan="9">Valuation Basis</td><td colspan="2">Evaluation Item</td><td>Allot</td><td>Obtain</td><td colspan="4">Remarks</td></tr>
<tr><td rowspan="4">Item point (80 point)</td><td>Prepare battery SOC estimation experiment</td><td>20</td><td></td><td colspan="4" rowspan="6"></td></tr>
<tr><td>Calculate the voltage value converted as a percentage</td><td>20</td><td></td></tr>
<tr><td>Voltage value calculation and graphing</td><td>20</td><td></td></tr>
<tr><td>Calculate battery capacity selection</td><td>20</td><td></td></tr>
<tr><td rowspan="2">Work point (10 point)</td><td>Work attitude and safety</td><td>5</td><td></td></tr>
<tr><td>Use, arrange, and dispose of materials tools</td><td>5</td><td></td></tr>
<tr><td rowspan="2">Time point (10 point)</td><td colspan="3" rowspan="2">Subtract (   ) point in every (   ) minute excess</td><td>Item</td><td>Work</td><td>Time</td><td>Total</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
</table>

Experiment name	12. Stand-alone inverter Efficiency Experiment	Class time(hr)
		8
Object	① Understand the principle of the inverter ② Inverter connection to battery ③ Establishment of stand-alone inverter system and calculation of efficiency	

Experiment equipment	Tool & material	Spec of tools	Q`nty
· Hybrid Power Conversion Experiment Equipment (KTE-HB520N)	· Driver	· #2× 6× 175㎜	1
	· Nipper	· 150㎜	1
	· Wire stripper	· 0.5~6㎟	1
	· Hook meter	· 300A 600V	1/Group

Control Circuit

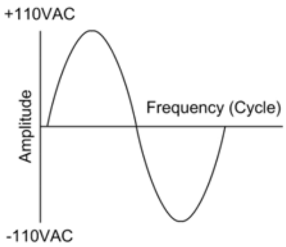


1. Circuit configuration
   (1) Connect the solar module in series or in parallel to the connection panel.
   (2) Connect the charger from the connection board.
   (3) Connect the battery from the charging controller.
   (4) Connect the battery to the inverter.
   (5) Connect the load from the inverter to the load.
2. Experimental method
   (1) Connect the bar screw to the bottom of the control panel and select the load capacity of each.
   (2) Measure the battery discharge voltage and current according to the load capacity and calculate the power value.

3. Stand-alone inverter

(1) Selecting method and efficiency relationship of inverter depending on load power usage capacity can be understood and explained. Because electricity generated from solar generating system is dc, it should be converted to ac voltage if it is intended to use in house or sell to grid. This can be divided into independent inverter and grid-connected inverter. Independent inverter is used regardless of grid, and inverter that sells the electricity to grid (power company) is called as grid-connected inverter. Independent inverter is divided into sine wavelength inverter and pure sine wavelength.

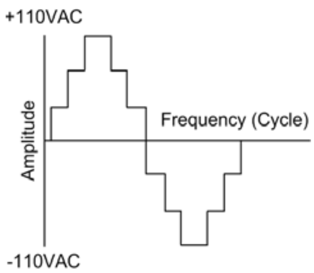
1) Pure Sine Wave Inverter



Pure sine wave

- It is the inverter that makes the sine wavelength and sends clean sine wavelength for wavelength of electricity supplied to house from grid (KOPEC).Electricity of this wavelength can be used in all ac electronic devices used in house, and independent solar generating system, measuring device, medical device, communication device, fluorescent light and computer should choose the sine wavelength inverter.

2) Modifide Sine Wave Inverter



Modified sine wave

- It is similar to sine wavelength, but distortion fo wavelength, if it reaches to rated power, phenomenon that wavelength is distorted occur, so surge is caused, and noise and image noise will occur. Because it is modified wavelength, it may not be used in sensitive electronic devices, and products that this wavelength can be used are non-sensitive motor, light and electric heater.

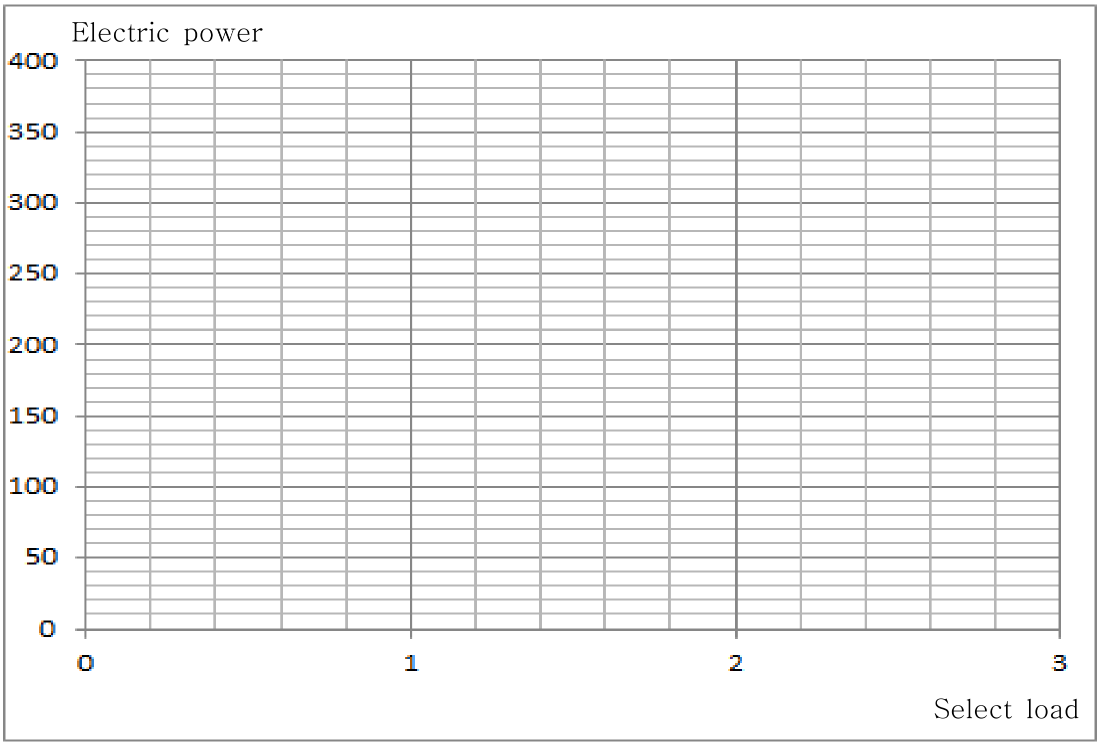
4. Connect the solar module or experiment after charging the battery with the DC supply.

(1) Mark in the table below the measured battery discharge voltage DCV, current DCI (A), and the inverter output voltage ACV current ACI, and calculate each power P (W). The efficiency of the inverter is also calculated.

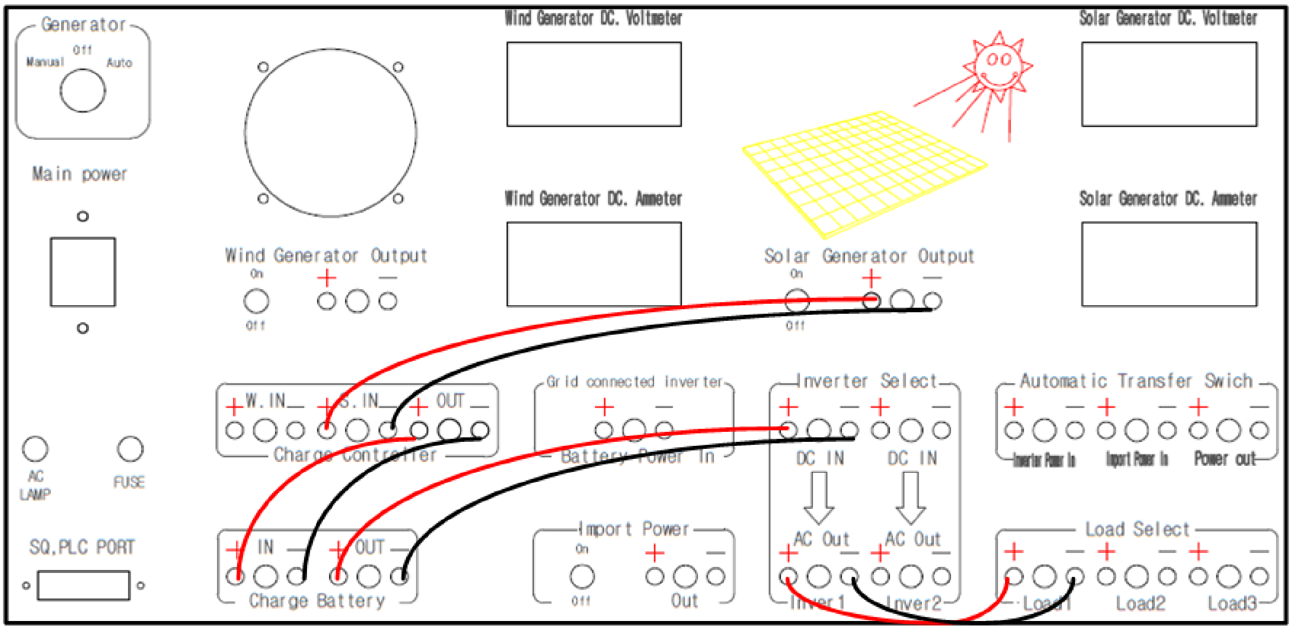
-Formula $Inverter\ efficiency(\eta) = \frac{DCP(W1)}{ACP(W2)} \times 100\%$

Load capacity	0	Load 1	Load 2	Load 3
DCV				
DCI				
DCP(W1)				
ACV				
ACI				
ACP(W2)				
Inverter efficiency(η)				

(2) Calculate the power value when connecting loads from the battery and the inverter, and plot together on the graph below.



5. Connection diagram



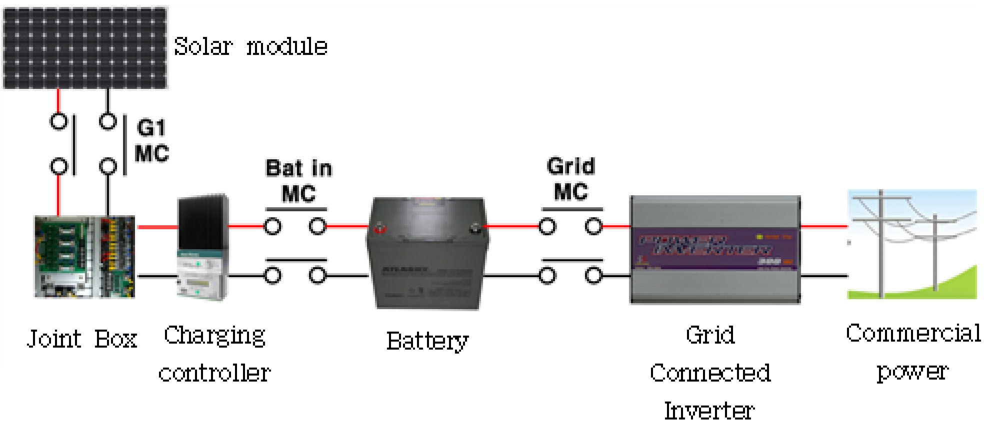
· Requirements

1. Prepare and inspect laboratory apparatus and tools.
2. Using experimental equipment and tools, construct and operate a stand-alone inverter connection.
3. Understand and describe the characteristics of stand-alone inverter.
4. Efficiency of stand-alone inverters can be calculated.
5. Calculate the inverter efficiency according to load capacity change.

<table>
<tr><td rowspan="10">Valuation Basis</td><td colspan="2">Evaluation Item</td><td>Allot</td><td>Obtain</td><td colspan="4">Remarks</td></tr>
<tr><td rowspan="4">Item point (80 point)</td><td>Prepare the Inverter Action Characteristics</td><td>20</td><td></td><td colspan="4" rowspan="6"></td></tr>
<tr><td>Battery discharge voltage, current measurement</td><td>20</td><td></td></tr>
<tr><td>Voltage value calculation and modulation</td><td>20</td><td></td></tr>
<tr><td>Inverter efficiency calculation</td><td>20</td><td></td></tr>
<tr><td rowspan="2">Work point (10 point)</td><td>Work attitude and safety</td><td>5</td><td></td></tr>
<tr><td>Use, arrange, and dispose of materials tools</td><td>5</td><td></td></tr>
<tr><td rowspan="2">Time point (10 point)</td><td colspan="3" rowspan="2">Subtract ( ) point in every ( ) minute excess</td><td>Item</td><td>Work</td><td>Time</td><td>Total</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
</table>

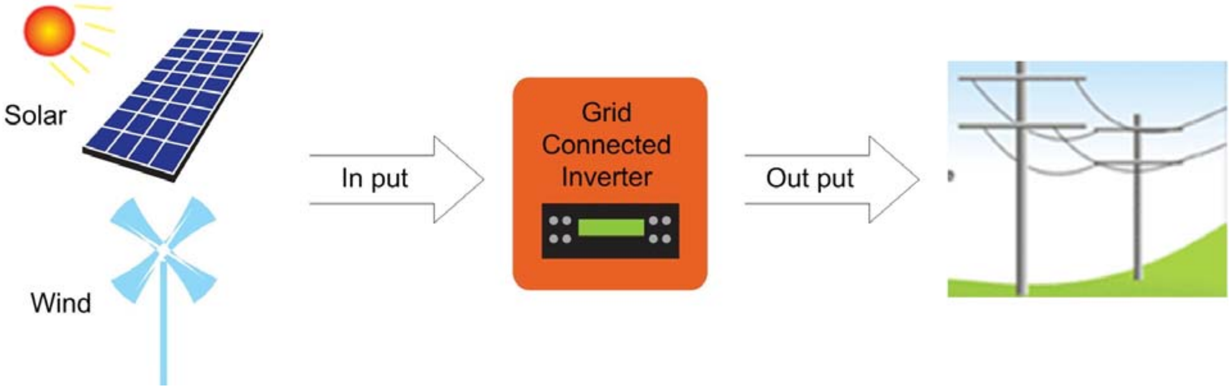
Experiment name	13. Practice of Configuration of Grid-connected Inverter			Class time(hr)
				8
Object	① Understand the system of the Grid-connected inverter ② Connecting the Gfid-connected inverter system ③ Understand the characteristics of the Grid-connected inverter operation			
Experiment equipment		Tool & material	Spec of tools	Q`nty
· Hybrid Power Conversion Experiment Equipment (KTE-HB520N)		· Driver · Nipper · Wire stripper · Hook meter	· #2× 6× 175㎜ · 150㎜ · 0.5~6㎟ · 300A 600V	1 1 1 1/Group

Control Circuit



1) Circuit configuration
   (1) Connect the solar module in series or in parallel to the connection panel.
   (2) Connect the Grid connection inverter in the connection panel.
2) Experimental method
   (1) Connect the bana jaek to each port of the control panel in order of circuit configuration.
   (2) Check if the power on the indicator of the system connection inverter is turned on, and when the system is connected, the direction of the inductive power meter rotates in reverse direction.

3. Grid connected inverter system



(1) What is grid-connected inverter system? Grid-connected inverter system supplies the remaining power from power supply of load, by connecting with commercial power system.

(2) Hardware configuration of grid-connected inverter consists of input section made to be supplied the dc safely from solar battery, power convert section that converts dc to ac, transformer that transforms the sizes of electric heating and voltage, main control panel to control each part, sensor and relay board that detects various signals and generates the contact point output for protection motion, auxiliarly power to supply the dc power needed for system and display and keypad that displays various indicators and is for setup/control.

(3) Unlike independent, grid-connected inverter system does not use the battery, and because it is the system that supplies the power remained from load directly to grid and equipped with grid-connected inverter, it can save the battery cost, so maintenance cost will be cheaper.

4. Precautions on Installation of Grid-Connected Inverter

(1) Install the instrument away from direct sunlight or hot temperatures without moisture or dust.

(2) When indoor, secure at least 20 cm at the upper and lower parts of the inverter.

(3) When outdoor is installed, secure at least one meter from the ground.

(4) Install the instrument directly by an expert.

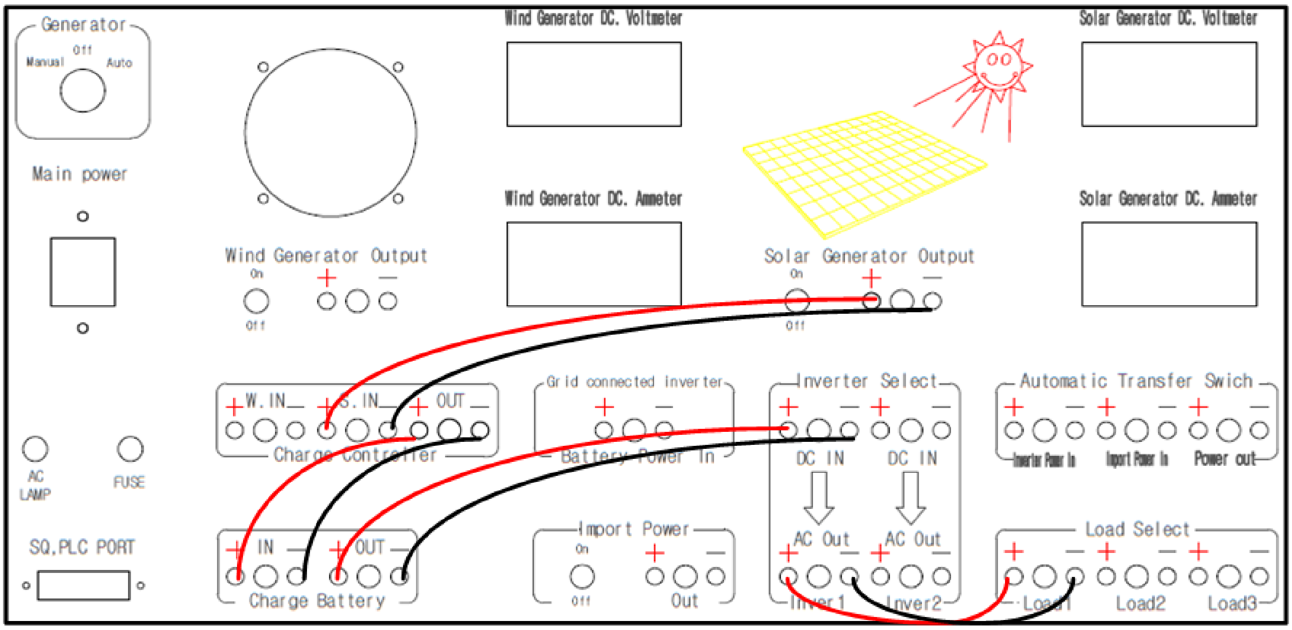
(5) Ground the three types of inverter (200V).

(6) Using other electronic appliances near the product may cause an abnormality or noise in the electronic appliances.

(7) If the PCB is detached during installation or repair, place it on the electrostatic field immediately after removal. It causes static electricity to damage the product.

(8) Before installing the inverter, install the solar cell power (DC) breaker to install the inverter and turn on the solar cell after it is switched off.

5. Connection diagram



· Requirements

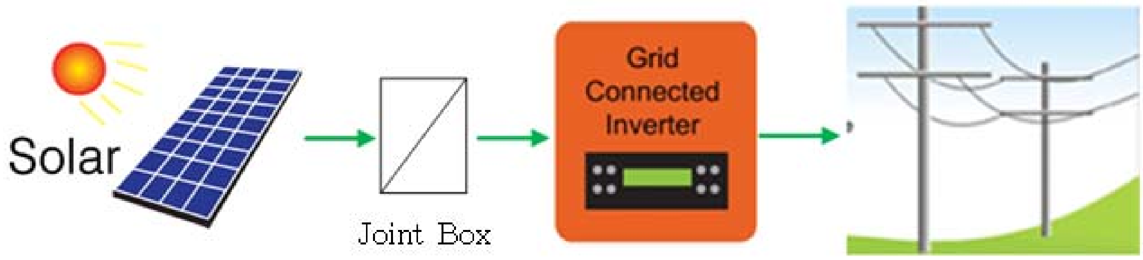
1. Prepare and inspect laboratory apparatus and tools.
2. Using experimental equipment and tools, construct and operate the connection circuit of the Grid-connected inverter .
3. Understand and describe the characteristics of the Grid-connected inverter .
4. Efficiency of Grid-connected inverter can be calculated.

Valuation Basis	Evaluation Item		Allot	Obtain	Remarks			
	Item point (80 point)	Prepare the Inverter Action Characteristics	20					
		Battery discharge voltage, current measurement	20					
		Voltage value calculation and modulation	20					
		Inverter efficiency calculation	20					
	Work point (10 point)	Work attitude and safety	5					
		Use, arrange, and dispose of materials tools	5					
	Time point (10 point)	Subtract ( ) point in every ( ) minute excess			Item	Work	Time	Total

Experiment name	14. Grid-connected inverter efficiency experiment	Class time(hr)
		8
Object	① Understand the principle of Grid-connected inverter ② Connecting the Grid-connected inverter system ③ Understand the characteristics of the Grid-connected inverter operation and efficiency	

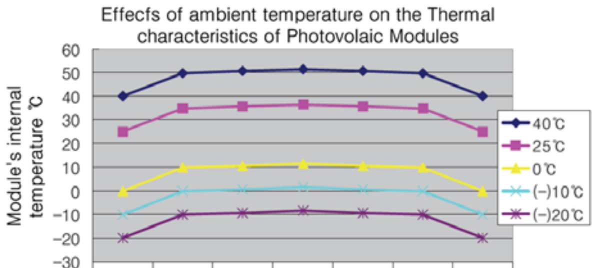
Experiment equipment	Tool & material	Spec of tools	Q`nty
· Hybrid Power Conversion Experiment (KTE-HB520N)	· Driver	· #2× 6× 175㎜	1
	· Nipper	· 150㎜	1
	· Wire stripper	· 0.5~6㎟	1
	· Hook meter	· 300A 600V	1/Group

Control Circuit



1) Circuit configuration
  (1) Connect the solar module in series or in parallel to the connection panel.
  (2) Connect the system connection inverter in the connection panel.
2) Experimental method
  (1) Connect the banana jack to each port on the control panel in order of circuit configuration.
  (2) After checking if the display panel of the system linkage inverter is turned on, check the voltage and current values of power generated and calculate the power values when the system is connected.
3. Design Requirements for Photovoltaic System
  (1) Any light-receiving elements such as mountain, tree and building, which overshadow solar cell modules, may result in reduction of power generation.
  (2) Any damage from salt or air pollution must be prevented by taking proper countermeasures for contact corrosion by dissimilar metals.
  (3) Any measure for review on former records of amount of snowfall, ice-up and lightening stroke must be duly established.
  (4) Any in-depth analysis on the history of natural disasters which occurred in installation area must be made.

4. Considerations on Temperature Coefficient for Selection of Grid-connected Inverter



	Back Sheet	EVA Sheet1	Ribbon1	Si Cell	Ribbon2	EVA Sheet2	Glass
40℃	40	49.799	50.616	51.433	50.616	49.799	40
25℃	25	34.8	35.617	36.433	35.617	34.8	25
0℃	0	9.8007	10.618	11.434	10.618	9.8007	0
(-)10℃	-10	-0.199	0.6179	1.4347	0.6179	-0.199	-10
(-)20℃	-20	-10.2	-9.382	-8.565	-9.382	-10.2	-20

Module Structure

(1) The temperature difference between the atmosphere and cell surface is approximately 10~11℃.

(2) When the atmospheric temperature is given, it is possible to estimate the voltage value of module.

* References

- Effects of Ambient Temperature on the Thermal Characteristics of Photovoltaic Modules by Kim Jongpil, Jeong Choonghwan, and Jang Yeongjoon [Excerpt from Collections of Dissertations, The Korean Solar Energy Society]

5. In case of a grid-connected inverter, where the solar cell modules are connected in series, there exist ranges of minimum operating voltage and maximum operating voltage, which also must be taken into account for design.

(1) The temperature characteristics of solar cell module shows that the coefficient of voltage = -0.312±0.015%/℃, which means that the voltage temperature coefficient is about -0.312. Each module has its original temperature coefficient, which can be used for the following formula to calculate the output voltage in line with the temperature change.

* Vmp + {((Surface Temperature) - 25℃) × Voltage Temperature Coefficient} = Output Voltage

(2) Where the atmospheric temperature is below -15℃ on a cold winter day, and

1) The module surface temperature is measured as about -4 ℃,

2) 29.3 + {((Surface Temperature) - 25℃) × Voltage Temperature Coefficient} = Output Voltage

a. 9.3V+{((-4)- 25℃)) ×-0.312} = 29.3 + 9.048= 38.348V

b. When the 16 modules are connected in series, 38.348*16 = 613.57V

c. Provided that the rated voltage of 29.3V is applied for the above, 29.3V*16=468.8V. However, if a grid-connected inverter, whose maximum operating voltage is 550V, is installed, the output voltage of 613.57V on a cold winter day may be judged as an overvoltage, which is likely to result in an operational failure.

6. Grid-connected Inverter System Design (3Kw Class for Individual House)

* Design Conditions

(1) Roof area must be approx. 40m²(8m*5m)

(2) Roof slope must be 35°

(3) Seasonal temperature range in installation area must be -15 ℃~ 40 ℃

(4) 230w PV Module, 1642*979*38mm, Voltage Temperature Coefficient(-0.312)

(5) 1st Step

1) Judgment on area suitability

a. Roof Breadth 8m / Module Length 1.642m = 4.87

b. Roof Length 5m / Module Breadth 0.979m = 5.1

2) Maximum number of modules by installation area is 4×5 = 20

3) How many modules are required for installation of 3KW Class?

a. Installation Capacity 3KW / Module Capacity 230W = 13

(6) 2nd Step

1) Check on electrical specification of module

2) Calculation of voltage range by module surface temperature

3) Seasonal temperature range in installation area must be -15 ℃~ 40 ℃

a. Formula. 29.3 + {((Current Temperature) - 25 ℃) × Voltage Temperature Coefficient}
= Output Voltage

b. Maximum Temperature Voltage

- 29.3 + {((-5 ℃)-25 ℃)×-0.312} = 38.66v

c. Minimum Temperature Voltage

- 29.3 + {((50 ℃)-25 ℃)×-0.312} = 21.5v

(7) 3rd Step

1) Decision on the maximum number of series connections of modules for selection of proper inverter

2) When the 13 modules are connected in series,

a. Minimum Operating Voltage of Inverter > 21.5v*13 Sheets = 279.5V

b. Maximum Operating Voltage of Inverter < 38.66v*13 Sheets = 502.58V

∴ The range of DC input voltage of a grid-connected inverter must be not lower than 200V and
not higher than 600V.

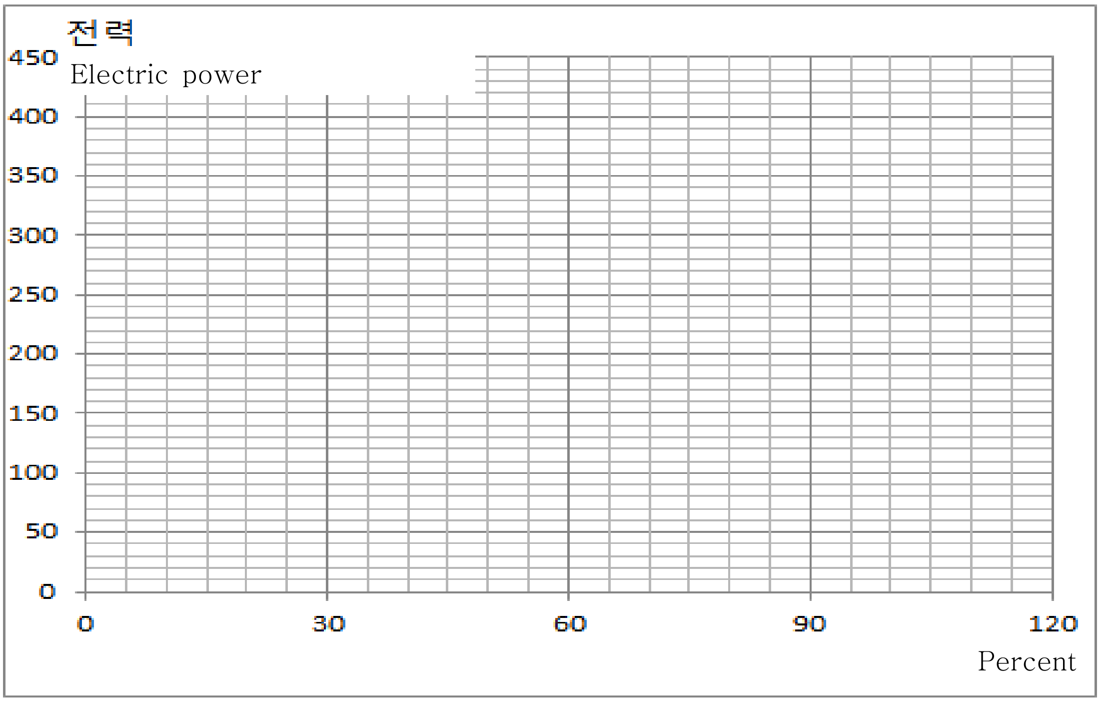
7. Connect the solar module or experiment after fully charging the battery with the DC supply.

(1) Calculate the measured battery discharge voltage DCV, current DCI (A), and the Grid-connected inverter output voltage, ACV current ACI, in the following table, and the respective power P (W). The efficiency of the inverter is also calculated.

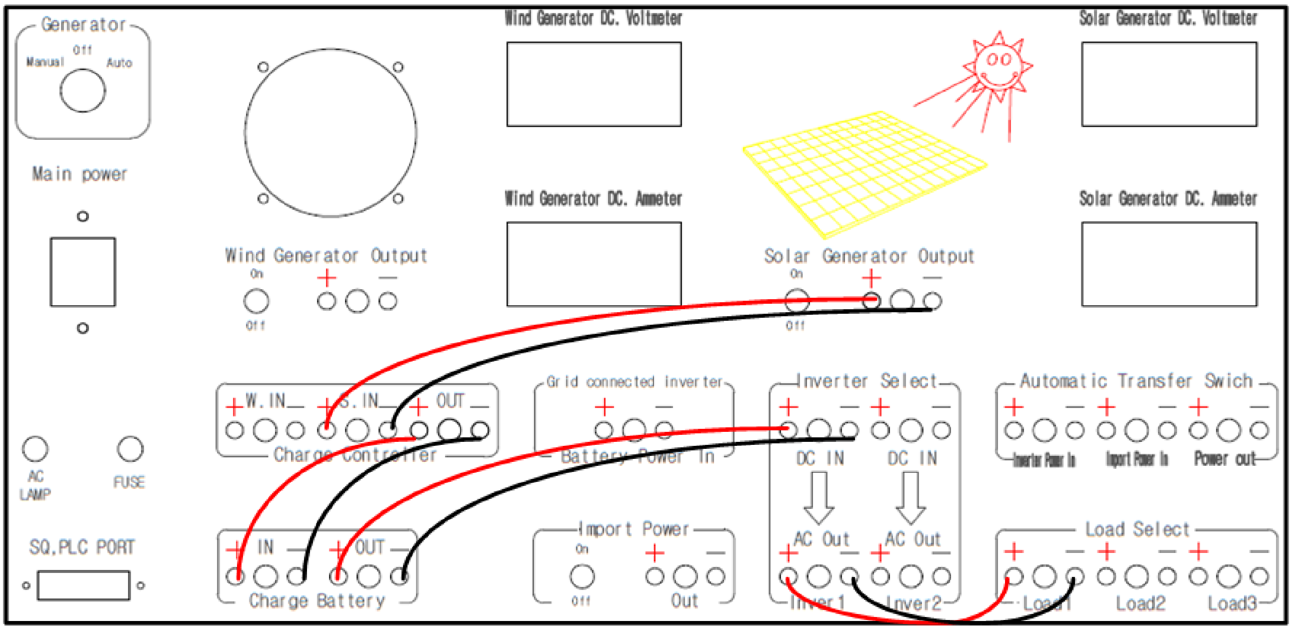
-Formula $Inverter\,efficiency(\eta) = \frac{DCP(W1)}{ACP(W2)} \times 100\%$

Experiment Time	0	30sec	60sec	90sec	120sec
DCV					
DCI					
DCP(W1)					
ACV					
ACI					
ACP(W2)					
Inverter efficiency(η)					

(2) Calculate the power value of the discharged power from the battery and the power of the Grid-connected inverter , and then plot together on the graph below.



8. Connection diagram



· Requirements

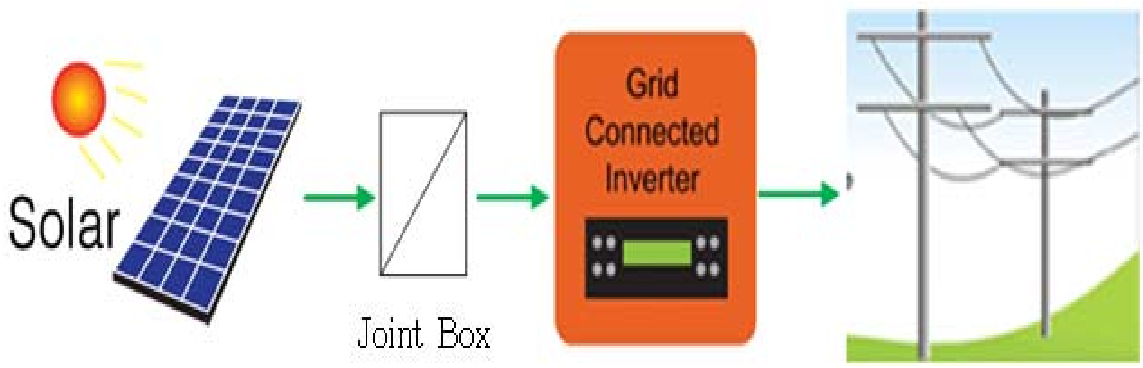
1. Prepare and inspect laboratory apparatus and tools.
2. Using experimental equipment and tools, construct and operate the connection circuit of the Grid-connected inverter .
3. Understand and describe the characteristics of the Grid-connected inverter .
4. Efficiency of Grid-connected inverter can be calculated.

<table>
<tr><td rowspan="8">Valuation Basis</td><td colspan="2">Evaluation Item</td><td>Allot</td><td>Obtain</td><td colspan="4">Remarks</td></tr>
<tr><td rowspan="4">Item point (80 point)</td><td>Prepare the Inverter Action Characteristics</td><td>20</td><td></td><td colspan="4" rowspan="6"></td></tr>
<tr><td>Battery discharge voltage, current measurement</td><td>20</td><td></td></tr>
<tr><td>Voltage value calculation and modulation</td><td>20</td><td></td></tr>
<tr><td>Inverter efficiency calculation</td><td>20</td><td></td></tr>
<tr><td rowspan="2">Work point (10 point)</td><td>Work attitude and safety</td><td>5</td><td></td></tr>
<tr><td>Use, arrange, and dispose of materials tools</td><td>5</td><td></td></tr>
<tr><td>Time point (10 point)</td><td colspan="3">Subtract (   ) point in every (   ) minute excess</td><td>Item
</td><td>Work
</td><td>Time
</td><td>Total
</td></tr>
</table>

Experiment name	15. Grid-connected inverter load operation experiment	Class time(hr)
		8
Object	① Understand the principle of the Grid-connected inverter ② Connecting the Grid-connected inverter system ③ Understand the characteristics of the pre - and post-integration operations of the system of the Grid-connected inverter	

Experiment equipment	Tool & material	Spec of tools	Q`nty
· Hybrid Power Conversion Experiment Equipment (KTE-HB520N)	· Driver · Nipper · Wire stripper · Hook meter	· #2× 6× 175㎜ · 150㎜ · 0.5~6㎟ · 300A 600V	1 1 1 1/Group

Control Circuit



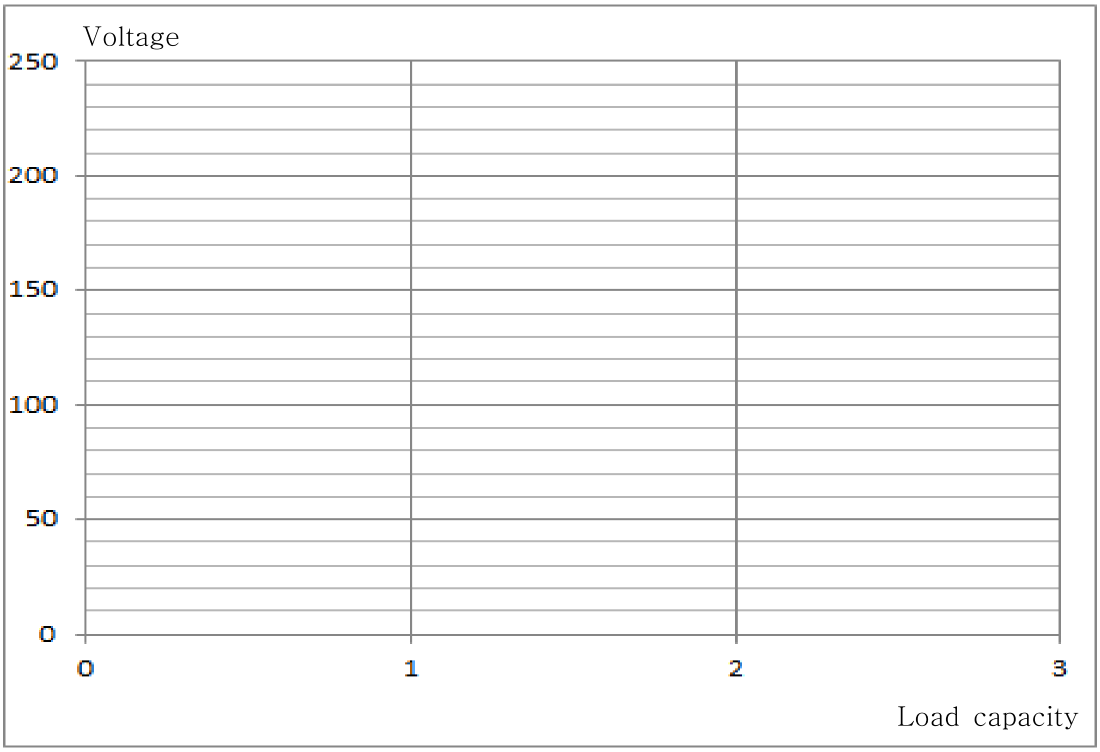
1) Circuit configuration
   (1) Connect the solar module in series or in parallel to the connection panel.
   (2) Connect the system connection inverter in the connection panel.
   (3) Connect the load.
2) Experimental method
   (1) Connect the banana jack to each port of the control panel in order of circuit configuration.
   (2) After checking if the display panel of the system linkage inverter is turned on, check the voltage and current values of power generated and calculate the power values when the system is connected in 300 seconds.
   (3) Measure the load when unloaded or when loaded.

3. Connect the solar module or experiment after fully charging the battery with the DC supply.

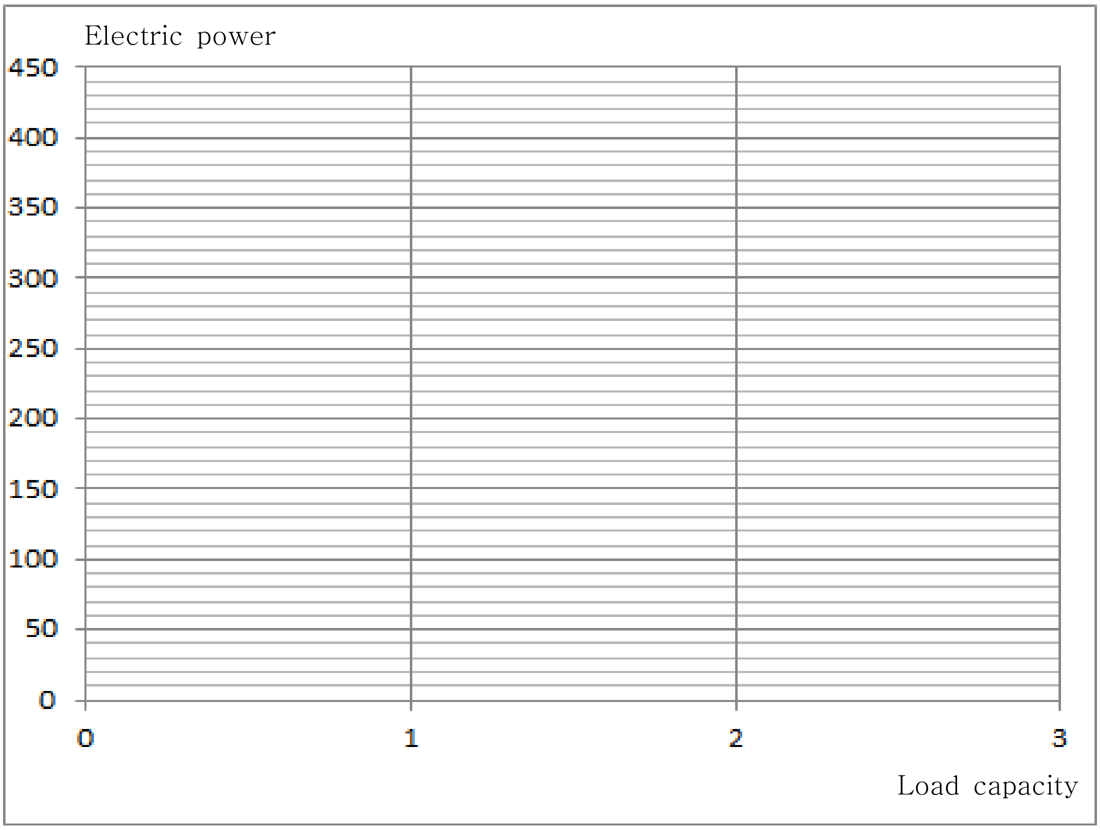
(1) Measure the voltage and current values of the connected inverter, the load side and the system side respectively, and calculate the values in the table below, respectively, by making a change in the load capacity prior to operation of the system interface inverter.

Load capacity	0	Load 1	Load 2	Load 3
Inverter V				
Inverter I(A)				
Generating power P(W)				
Load V				
Load I(A)				
Load Power P(W)				
System V				
System I(A)				
System power P(W)				

(2) The output voltage to the inverter, the voltage to the load side and the voltage to the system are plotted in the graphs below.



(3) The output power to the inverter, the load side power and the system side power are plotted in the graphs below.

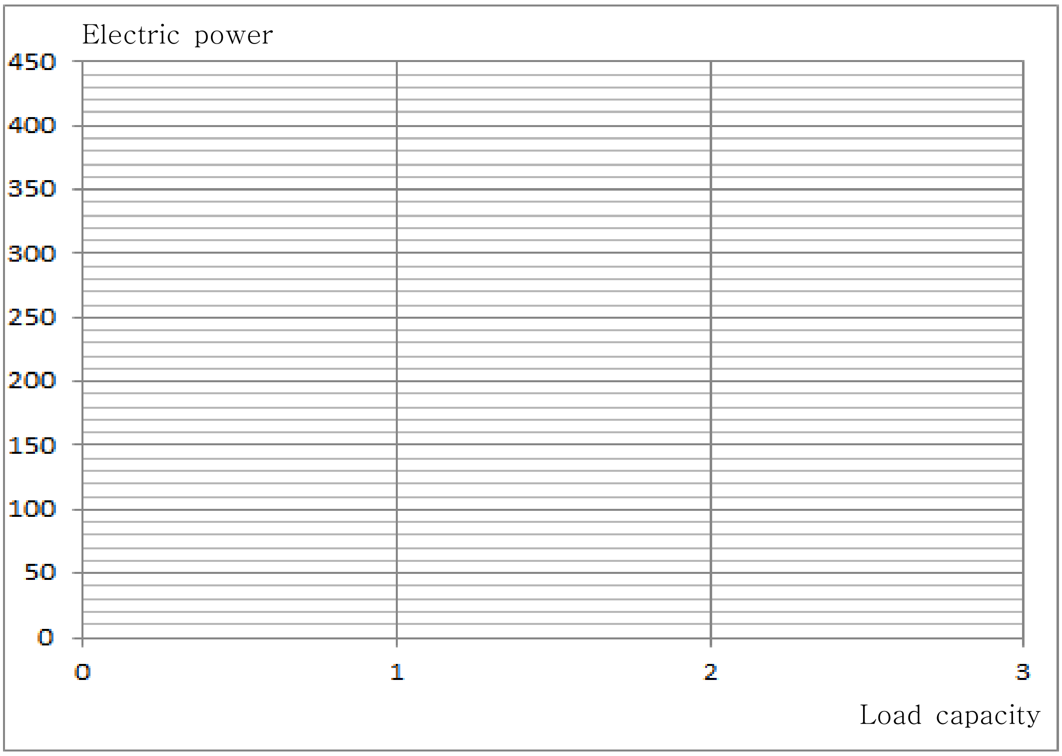


(4) After operating the Grid-connected inverter , measure the voltage and current values of the connected inverter, the load side and the system side respectively, and record the values in the table below.

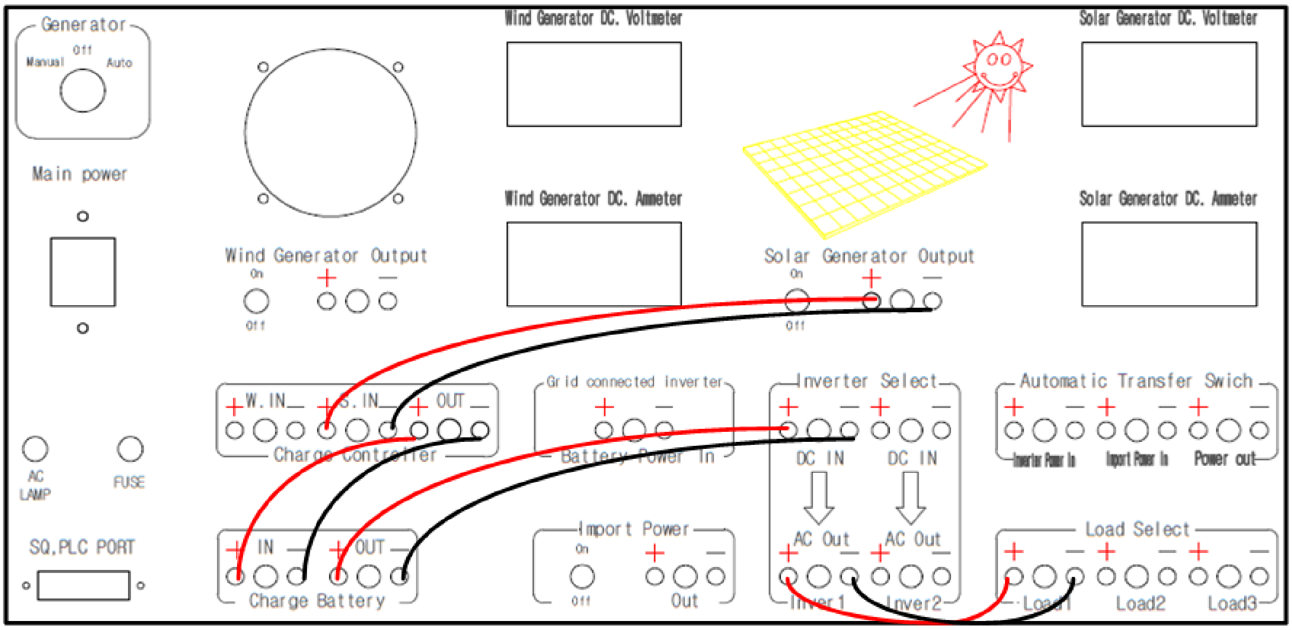
Load capacity	0	Load 1	Load 2	Load 3
Inverter V				
Inverter I(A)				
Generating power P(W)				
Load V				
Load I(A)				
Load Power P(W)				
System V				
System I(A)				
System power P(W)				

(5) The output voltage to the inverter, the voltage to the load side and the voltage to the system are plotted in the graphs below.

(6) The output power to the inverter, the load side power and the system side power are plotted in the graphs below.



4. Connection diagram



· Requirements

1. Prepare and inspect laboratory apparatus and tools.
2. Using experimental equipment and tools, construct and operate the connection circuit of the Grid-connected inverter .
3. The characteristics of the Grid-connected inverter is not connected to the system are explained.
4. The characteristics of the Grid-connected inverter is described in the system.
5. The Grid-connected inverter changes the capacity of the loads after connecting to the system.

Valuation Basis	Evaluation Item		Allot	Obtain	Remarks			
	Item point (80 point)	Prepare the Inverter Action Characteristics	20					
		Inverter Output Voltage, Current Measurement	20					
		Load Side Consumption Voltage, Current Measurement	20					
		Current measurement	20					
	Work point (10 point)	Work attitude and safety	5					
		Use, arrange, and dispose of materials tools	5					
	Time point (10 point)	Subtract ( ) point in every ( ) minute excess			Item	Work	Time	Total

6. Installing and Using the Test Equipment

6-1. Installation of the Fixed Solar Generator

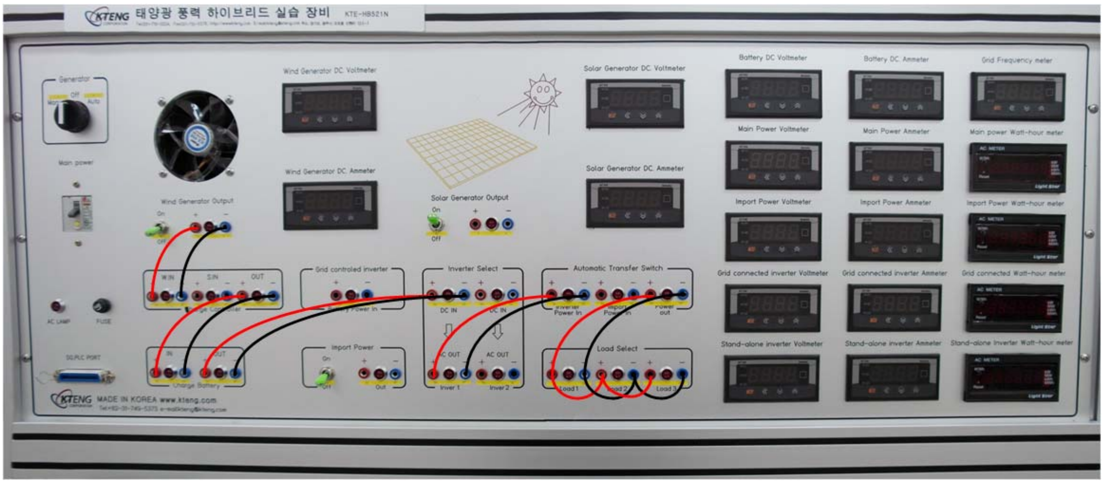
(1) Install the generator on a flat floor surface by stably fixing the body on the floor, so that it does not move while operating.

(2) Connect the power cablese on solar modules in series or parallel to connect with terminals on the access panel of the solar electric conversion test equipment.

6-2. Installation of Electric Conversion Test Equipment

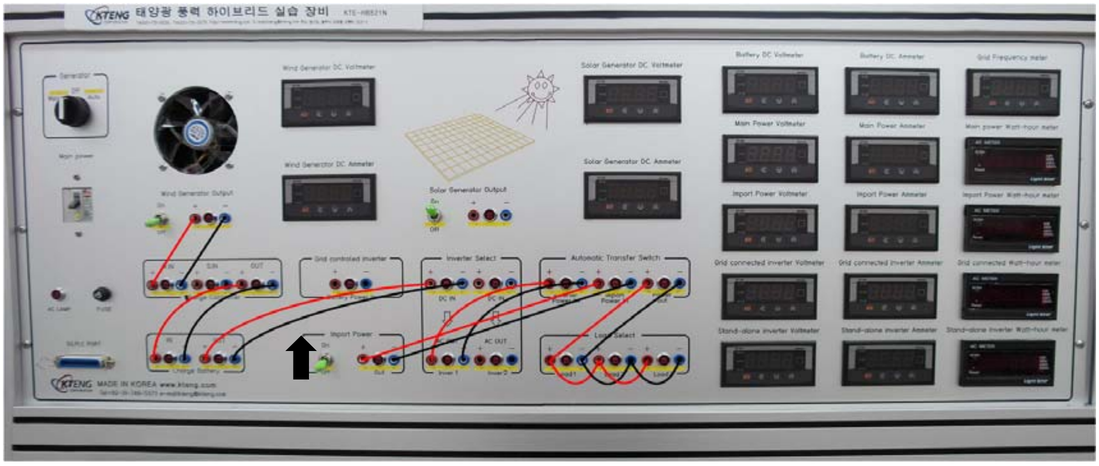
Move the test equipment to where power is available and connect 220V AC power cable to the power terminal at the back of the control panel. Then, plug the power cable to start supplying power to the test equipment.

(1) Stand-alone inverter Power Generation System Configuration Connection



(2) Grid-connected inverter Power Generation System Configuration Connection

(3) Automatic switching switch system configuration using commercial power connection



7. Cautions in Handling the Equipment

7-1. Power Supply

(1) The main power of AC220V is used to operate the test system.

(2) The procedure of operating the system is as follows. While the power is connected, turn the N.F.B on and complete wiring using banana jacks according to the circuit diagram. Then turn the DC toggle switch on the solar generator on.

(3) Using banana jacks to supply DC24V of power on the system is safe, but make sure not to confuse + and – terminals since it operates with DC .

(4) Moreover, since all components of the system, including the base and the control panel, are made of aluminium, make sure not to touch the aluminium when connecting with the + terminal, red colored terminal.

7-2. General Conditions

(1) Make sure to thoroughly read and understand the manual before starting to use the system.

(2) You may be charged for A/S services regarding malfunctioning due to dissembling or modification of the equipment, even during the warranty period.

(3) For any other inquiries about the operation, malfunctioning or using method of the system, feel free to contact the head office.

◎ Certificate of Patent

CERTIFICATE OF PATENT

PATENT NUMBER 10-0952929

APPLICATION NUMBER 2009-0103301
FILING DATE Oct. 29. 2009
REGISTRATION DATE Apr. 07. 2010

TITLE OF THE INVENTION Complex Power Conversion Equipment

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Bundang-gu Seongnam-si Gyeonggi-do Korea

THIS IS TO CERTIFY THAT THE PATENT IS REGISTERED ON THE REGISTER OF THE KOREAN INTELLECTUAL PROPERTY OFFICE

Apr. 07. 2010

COMMISSIONER,
THE KOREAN INTELLECTUAL PROPERTY OFFICE

CERTIFICATE OF UTILITY MODEL REGISTRATION

REGISTRATION NUMBER 20-0449478

APPLICATION NUMBER 2009-0014127
FILING DATE Oct. 30. 2009
REGISTRATION DATE Jul. 06. 2010

TITLE OF THE DEVICE Artificial Sunlight Equipment

OWNER OF THE UTILITY MODEL RIGHT
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Seongnam-si Gyeonggi-do Korea

DEVISER
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122-701 Jangan town Kunyoung Apt., Bundang-dong
Bundang-gu Seongnam-si Gyeonggi-do Korea

THIS IS TO CERTIFY THAT THE DESIGN IS REGISTERED ON THE REGISTER OF THE KOREAN INTELLECTUAL PROPERTY OFFICE

Oct. 25. 2010

COMMISSIONER,
THE KOREAN INTELLECTUAL PROPERTY OFFICE

CERTIFICATE OF UTILITY MODEL REGISTRATION

REGISTRATION NUMBER 20-0447670

APPLICATION NUMBER 2009-0008945
FILING DATE Jul. 10. 2009
REGISTRATION DATE Feb. 03. 2010

TITLE OF THE DEVICE Educational Energy Collection Equipment

OWNER OF THE UTILITY MODEL RIGHT
KTENG Co. Ltd., (141111-0******)
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Feb. 03. 2010

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NO. C-2009-000406

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2. Work Type	Literature
3. Register name	KTENG Co.,Ltd.
4. Corporate company registration No.	141111-0019270
5. Copyright owner	
6. Corporate company No.	
7. Creative date	Dec. 30. 2009
8. Announce date	
9. Reference	Owner : KTENG Co.,Ltd. Creative July. 14. 2008
10. Registration date	Dec. 30. 2009

This has been registered with regarding as article 53 in the law of copyright.

Jan. 08. 2010

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◎ Warrantee and A/S application sheet

Product Warrantee Certification

Fill out this sheet, and send by Fax or E-mail..

MODEL		
WARRENTEE TERM	1 YEAR	
PURCHASING DATE	(M/D/Y)	
ORGANIZATION	**SCHOOL**	
	DEPARTMENT	

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