CPE-EN4500

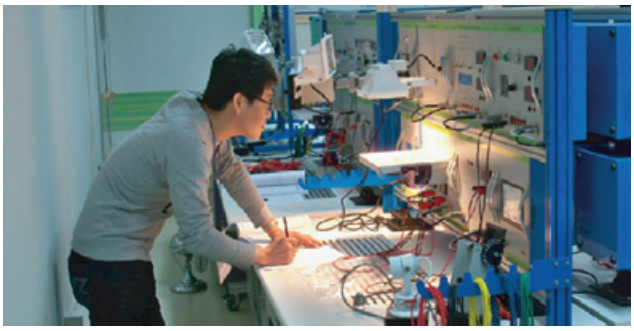
Smart Grid (Solar/Wind/Fuel Cell) Training System

FEATURES

- Integrated training system designed to help the user learn basic principles of renewable energy and practice circuit configuration throughout theory verification and simulation
- Hands-on power control practices covering various power generation system: off-grid, grid-tied, hybrid and smart grid
- Voltage /current/load experiments per grid in both solar PV and wind power generation
- Modularized structure with a modular rack for easy attachment and detachment of modules
- Rigid and durable worktable in aluminum profile structure, plus module storage drawers allowing user convenience in keeping experimental modules safe
- Supports various experiments in relation to a shift in the position of the Sun by applying the artificial light source
- With charging controller and rechargeable batteries for energy restoration
- Use an Inverter to practice an AC load experiment
- Standalone or integrated monitoring on the voltage and current values of experimental modules

EXPERIMENTAL CONTENTS

- Basic principles of solar PV power generation
- Solar PV system related practices
- Characteristics of power generation by the solar amount
- Electrical characteristics such as open circuit voltage and short-circuit current
- I-V, P-V characteristics by the incidence angle of solar modules
- I-V, P-V characteristics according to the distance of solar modules
- I-V, P-V characteristics based on the temperature characteristics of solar modules
- I-V, P-V characteristics based on the irradiance of solar modules
- V-I characteristics and load in solar generation according to the solar cell connection in series or parallel
- Battery charge-discharge practices using a charging controller
- Power conversion through the off-grid inverter
- Power conversion through the grid-tied inverter
- Smart grid monitoring practices with the voltage value and current value per system
- Streetlight control practice based on sunrise and sunset
- MPPT control practice
- Principles and systems of wind power generation
- Characteristics of a wind power generator in terms of rotating speed and load
- Characteristic curves of hydrogen electrolysis
- The faraday efficiency and electrolysis's energy efficiency
- Principles and systems of electrical power generation from a hydrogen fuel cell
- Characteristic curves of a fuel cell connected in series or parallel
- Hydrogen fuel cell's characteristics in terms of power generation amount and load
- Solar PV-Wind hybrid power generation
- Solar PV-Hydrogen hybrid power generation
- Wind-Hydrogen hybrid power generation
- Solar PV-Wind-Hydrogen hybrid power generation
- Data measurement and control practice using RS-485 serial port



PRODUCT COMPOSITON

• Experimental Module package (3 types)

Hybrid & Smart Grid Electric Power Control					
Grid-Tied Solar Power Generation (* Wind Generator: Optional)			PK2	PK3	Option
Off-Grid Solar PV Power Generation (* Wind Generator: Optional)		PK1			
• CPE-EN4500-T01	Experimental Table Set	O	O	O	
• CPE-EN4500-M01	AC Power Source Module	O	O	O	
• CPE-EN4500-M02	Arm Type Light Source Module	O	O	O	
• CPE-EN4500-M03	Photovoltaic Cell Module A	O	O	O	
• CPE-EN4500-M04	Photovoltaic Cell Module B	O	O	O	
• CPE-EN4500-M05	Hybrid Charging Controller Module	O	O		
• CPE-EN4500-M06	Battery Bank Module	O	O		
• CPE-EN4500-M07	Stand-alone Inverter Module	O	O		
• CPE-EN4500-M08	DC Load Module	O	O	O	
• CPE-EN4500-M09	AC Load Module	O	O		
• CPE-EN4500-M11	Automatic Charger Module	O	O	O	
• CPE-EN4500-M12	Wind Generator Module (Propeller type)	* (option)	* (option)	O	
• CPE-EN4500-M13	Photovoltaic Cell Connection Module	O	O	O	
• CPE-EN4500-M15	Hydrogen Load & DC/DC Converter Module			O	
• CPE-EN4500-M16	Hydrogen Generator Module			O	
• CPE-EN4500-M18	Multi-type Battery Bank Module				O
• CPE-EN4500-M19	Multi-type Charging Controller Module				O
• CPE-EN4500-M20	Multi-type Grid-Connected Inverter Module			O	
• CPE-EN4500-M21	Distributed Power Control Module			O	
• CPE-EN4500-M22	Smart Home Appliance Load Module			O	
• CPE-EN4500-M23	AC Meter Module			O	
• CPE-EN4500-OP1	Smart Grid Monitoring Module	O	O	O	
• CPE-EN4500-OP2	Virtual Photovoltaic Array Module				O
• CPE-EN4500-OP3	1.2kw Grid Connected Inverter Module				O
• CPE-EN4500-OP4	Adjustable Angle Solar Module	O	O	O	
• CPE-EN4500-OP5	Electricity Meter Module		O		
• CPE-EN4500-OP6	MPPT Module		O	O	
• CPE-EN4500-OP8	DC Meter Module				O
• CPE-EN4500-OP9	Analog Watt Hour Meter Module		O		
• CPE-EN4500-OP10	300W Grid Connected Inverter Module		O		

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SPECIFICATIONS

EXPERIMENTAL TABLE SET

1) Worktable : 1ea
 - Structure: Aluminum profile
 - Upper plate : HPM lumber (at intervals of 25mm)
 - Caster (noise-reduction type): 4ea
 - Dimension : 1600(W) x 800(D) x 820(H)mm
 - AC 220V Outlet : 2ea
2) Module storage drawers : 2ea
 - with hinged doors and module slots
3) Frame for experimental modules : 1ea
 - Structure: Slot board type in Aluminum profile (at intervals of 25mm)
 Easy attachment/detachment of experimental modules
 - Size : 900(W) x 305(D)mm
4) Experimental modular rack
 - Structure: Double stack structure in Aluminum Profile
 - Module fixation: Up-and-down railway type
 - Size : 1,600(W) x 750(H)mm

AC POWER SOURCE MODULE (M01)

1) ELCB (AC220V 60Hz, 15A/15mA): 1ea
2) AC inlet (with built-in fuse, 5A) : 1ea
3) AC power lamp : 1ea
4) Earth connection terminal (insulation type): 1ea
5) AC 220V output connector (3/4pin) : 1ea
6) AC 220V module connection cord (3/4pin) : 1ea
7) Dimension : 250(W) x 309(D) x 120(H)mm

LIGHT SOURCE MODULE (M02)

1) Output : 300W
2) Power : 220V 50/60Hz
3) Halogen lamp
4) Heat-resistant glass
5) Dimming control : 0~100%
6) Arm attachment type

PHOTOVOLTAIC CELL [A] MODULE (M03)

1) Solar cell
 - Maximum power (pm) : 5W
 - Maximum power voltage (Vmp) : 17.5V
 - Maximum power current (Imp) : 300mA
 - Open-circuit voltage (Voc) : 21.4V
 - Short-circuit current (Isc) : 390mA
2) PV output terminal (4mm) : 1set
3) Dimension : 380(W) x 309(H) x 120(D)mm

PHOTOVOLTAIC CELL [B] MODULE (M04)

1) Solar cell
 - Maximum power (pm) : 0.5W
 - Maximum power voltage (Vmp) : 6V
 - Maximum power current (Imp) : 85mA
 - Open-circuit voltage (Voc) : 6.6V
 - Short-circuit current (Isc) : 95mA
2) PV output port (PV1~PV6) : 1set
3) Dimension : 380(W) x 120(D) x 309(H) mm

HYBRID CONTROLLER MODULE (M05)

1) Charging controller
 - Normal voltage : 12V
 - Boost voltage : 13.5V (25℃), 2 hours
 - Equalization voltage : 14.8V (25℃), 2 hours
 - Float voltage : 13.7V (25℃)
 - Low voltage defense (LVD) : 11.4~11.9V (controlled by a charged state), 11.0V (controlled by voltage)
 - Load re-connection voltage : 12.8V
 - Temperature compensation : -4mV/Cell*k
 - Maximum input current (Solar Panel) : 5A / 8A / 10A / 15A / 20A
 - Maximum load current (Load) : 5A / 8A / 10A / 15A / 20A

4) PV input terminal (4mm) : 1set
5) Battery input terminal (4mm) : 1set
6) 4mm output terminal: DC load output (1set) and inverter output (1set)
7) Dimension : 380(W) x 120(D) x 309(H) mm

BATTERY MODULE (M06)

1) Battery (12V, 7AH) : 2ea
2) Battery output terminal (4mm) : 1set
3) DC Voltmeter : 1ea
 - Maximum measuring input : DC500V
 - Maximum display range : -1999 ~ 9999
 - Hi/Low scale function
 - AC frequency measurement (0.1 ~ 9999Hz)
 - Communication : RS485
 - Voltage input terminal (4mm) : 1set
4) Dimension : 380(W) x 120(D) x 309(H) mm

STAND-ALONE INVERTER MODULE (M07)

1) Inverter
 - Output (AC): 300W 60Hz frequency
 - Input (DC):
 Low voltage (warning at 10.5±0.3V / automatic shut-down in case of 10.5±0.3V)
 High voltage (automatic shutdown in case of 16.5V or higher)
 - Protection function: Overheat, short-circuit, overload
 - Warning function: Alarm sound and red LED lamp (low battery power or overheat notice)

4) AC outlet (AC220V): 1ea
5) Power switch: 1ea
6) Inverter alarm monitoring lamp: 1ea
7) DC input terminal (4mm / 10.5V ~ 16.5V): 1set
8) AC output terminal (4mm) : 1set
9) Dimension : 380(W) x 120(D) x 309(H) mm

DC LOAD MODULE (M08)

1) DC lamp and socket (DC12V/10W) : 2ea
2) Buzzer (DC12V) : 1ea
3) Fan (DC12V, with protection cover) : 1ea
4) Variable resistor (Open, 60 Ω /30 Ω /20 Ω /15 Ω /12Ω) : 1ea
5) DC input terminal (4mm) : 1set
6) Load selector switch (for standalone control of lamp-1, lamp-2, buzzer, fan and resistor) : 1set
7) Dimension : 380(W) x 120(D) x 309(H) mm

AC LOAD MODULE (M09)

1) AC lamp and socket (AC220V) : 2ea
2) Buzzer (AC220V) : 1ea
3) AC motor (AC220V, rotary disc type) : 1ea
4) AC motor variable power controller : 1ea
5) AC input terminal (4mm) : 1set
6) Load switch (for standalone control of lamp-1, lamp-2, buzzer and motor: 1set
7) Dimension : 380(W) x 120(D) x 309(H) mm

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SPECIFICATIONS

AUTOMATIC CHARGER MODULE (M11)

1) Indication lamp: Fully charged battery
   Battery charging in progress
2) Selector for a charging voltage: 13.4V or 14.4V
3) Charging current: Rated current 10A
4) Function:
   Output short-circuit protection
   High efficient automatic charging
   Reverse polarity protection (DC output cut-off)
5) AC Inlet (with built-in fuse): 1ea
6) DC output terminal (4mm): 1set
7) Insulated ground connection terminal: 1ea
8) Dimension: 380(W) x 120(D) x 309(H) mm

WIND GENERATOR MODULE (M12)

1) Rated output : 3W
2) WV output terminal : 1set
3) Dimension: 380(W) x 120(D) x 309(H) mm

PHOTOVOLTAIC CELL CONNECTION MODULE (M13)

1) Schottky diode (reverse current protection): 6ea
2) Bypass Schottky diode: 6ea
3) I/O terminal: 24ea
4) DC voltmeter (2ea) and DC ampere meter (2ea)
   - Maximum measuring input : DC 500V, DC 5A
   - Maximum display range : -1999 ~ 9999
   - AC frequency measurement: 0.1 ~ 9999Hz
   - Communication: RS485
   - Voltage input terminal (4mm): 1set
   - Current input terminal (4mm): 1set
5) Dimension : 380(W) x 120(D) x 309(H) mm

HYDROGEN LOAD & DC/DC CONVERTER MODULE (M15)

1) DC voltmeter (2ea) and DC digital ampere meter (1ea)
   - Maximum measuring input: DC 500V, DC 5A
   - Maximum display range: -1999 ~ 9999
   - Communication type: RS485
   - Voltage input terminal (4mm): 1set
   - Current input terminal (4mm): 1set
2) Load resistor : 0.3 Ω/0.5 Ω/1 Ω/2 Ω/3 Ω /5 Ω /10 Ω /20 Ω /50 Ω /100Ω/Open
3) DC/DC converter: 1ea
   - Input: DC 1.2V ~ 2V
   - Output DC: 12V
4) Auto charger function
5) Dimension : 380(W) x 120(D) x 309(H) mm

HYDROGEN GENERATOR MODULE (M16)

1) Electrolyzer : 1ea
   - Voltage at continuous operation : 1.4V ~ 1.8V
   - Voltage at peak load periods: 2.0V
   - Current : 0 ~ 4000mA
   - Hydrogen production : Max. 28㎖/min
   - Hydrogen and Oxygen storage tank (Transparent type)
2) 2PEM Fuel Cell : 1ea
   - Membrane surface area : 2 x 10㎠
   - Voltage output : Parallel connection (0.4V ~ 1.0V)
     Serial connection (0.8V ~ 2.0V)
   - Current output : Parallel connection (max. 4000㎃)
   - Hydrogen consumption : Max. 28㎖/min (at 4000㎃)
3) Power supply : Fixed 1.8V 2A (max.)
4) Connection tube : 1set
5) Dimension: 380(W) x 120(D) x 309(H) mm

MULTI-TYPE BATTERY BANK MODULE (M18)

1) Battery(12V, 7AH) : 3ea
2) Battery output terminal (4mm) : 3sets
3) Power switch (3ea) and power display (3ea)
4) Dimension: 380(W) x 120(D) x 309(H) mm

MULTI-TYPE CHARGING CONTROLLER MODULE (M19)

1) Charging Controller: 3ea
 - Normal voltage: 12V
 - Boost voltage: 13.5V(25℃), 2hrs
 - Equalization voltage: 14.8V(25℃), 2hrs
 - Float Voltage: 13.7V(25℃)
 - Status indicator (5-step): 3sets
2) DC voltmeter (3ea) and
 DC digital ampere meter (3ea)
 - Maximum measuring input: DC 500V, DC 5A
 - Maximum display range: -1999 ~ 9999
 - Communication type: RS485
 - Voltage input terminal (4mm): 1set
 - Current input terminal (4mm): 1set
3) PV terminal (4mm): 3sets
4) Battery terminal (4mm) : 3sets
5) Output terminal (4mm): 3sets
6) Dimension: 380(W) x 120(D) x 309(H) mm

MULTI-TYPE GRID CONNECTED INVERTER MODULE (M20)

1) Grid connected inverter: 3ea
 - Rated AC output : 270W
 - Maximum AC output : 300W
 - DC input voltage range : 10.8V ~ 30V
 - Rated output : AC 220V 60 Hz
2) PV input terminal (4mm) &
 ON/OFF switch: 3sets
3) AC output terminal (4mm) & indicator : 3sets
4) Dimension: 380(W) x 120(D) x 309(H) mm

DISTRIBUTED POWER CONTROL MODULE (M21)

1) Commercial electricity grid-connection and regional power generation (renewable energy)
2) Facing short circuit and overload of commercial electricity: Supply of power by regional generation
3) Facing short circuit and overload of regional generation: Supply of power by the user's setting
4) Smart grid function: Distributed generation control
5) AC input terminal (4mm) and indicator lamp: 3sets
6) Digital AC power meter (regional generation measurement): 3ea
7) Digital watt-hour meter (regional generation & load measurement): 2ea
8) AC output outlet (1ea) and indicator lamp (1ea)
9) AC power inlet (1ea), circuit breaker (1ea) and indicator lamp (1ea)
10) Dimension: 380(W) x 120(D) x 309(H) mm

SMART HOME APPLIANCE LOAD MODULE (M22)

1) Smart home appliance 1 - Lighting (LED lamp)
2) Smart home appliance 2 - Electric fan (AC fan with variable speed)
3) Smart home appliance 3 - Washing machine (AC motor with dimming Control)
4) Smart home appliance 4 - Continuously variable load
5) Digital AC power meter: 1ea
6) Smart home appliance power outlet: 1ea
7) Smart home appliance ON/OFF control switch: 4ea
8) Dimension: 380(W) x 120(D) x 309(H) mm

SMART GRID MONITOR MODULE (OP1)

1) Smart Grid Monitor: 1ea
 - Operating system: Windows CE 5.0
 - User Interface: RS485 and USB
 - Development environment: Microsoft eMbedded Visual C++ 4.0 and Visual Studio 2005
 - CPU: 32Bit RISC MP2530F (700 MIPS Performance)
 - Memory: RAM: DDR 64MB+32MB
 NAND: 64MB
 SUB: SD-CARD / 1.8" IDE HDD (option)
 - Touch screen LCD: 7" wide & LED backlight
 - Power : 12V 500mA
 - Monitoring the voltage and current values of experimental modules
2) Download interface: USB
3) Dimension: 380(W) x 120(D) x 309(H) mm

AC METER MODULE (M23)

1) Digital AC power meter: 1ea
2) Insulated input terminal (4mm): 2sets

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SPECIFICATIONS

VIRTUAL PHOTOVOLTAIC ARRAY MODULE (OP2)

1) Output Voltage : 0 ~ 100VDC
2) Output Current : 0 ~ 15ADC
3) DC Output terminal (0 ~ 100VDC 15A) : 1set
4) Voltage setting knob : 1ea
5) Current setting knob: 1ea
6) Dimension: 380(W) x 120(D) x 309(H) mm

GRID CONNECTED INVERTER MODULE (OP3)

1) Rated input : DC 48V ~ 100V 15A
2) Rated output : AC 220V 60Hz, 1kW
3) Inverter power level display : 4 steps
4) Import watt-hour meter: 1ea
5) Export watt-hour meter : 1ea
6) AC power line ELCB (AC220V 60Hz, 15A / 15mA) : 1ea
7) AC Load Circuit ELCB (AC220V 60Hz, 15A / 15mA) : 1ea
8) DC ON/OFF circuit breaker: 1ea
9) Insulated DC input terminal (48 ~ 100VDC 15A, 4mm) : 1set
10) AC power line inlet (AC 220V 60Hz & built-in fuse) : 1ea
11) AC load outlet (AC 220V 60Hz) : 1ea
12) Insulated AC output terminal (4mm) : 1set
13) Dimension: 380(W) x 240(D) x 309(H) mm

ADJUSTABLE ANGLE OF SOLAR MODULE (OP4)

1) PV Cell
 - One-touch clamp in two mountable positions
 - Adjustable angle: Up / down / left / right
 - Vmpp : 4.08V
 - Voc : 4.92V
 - Impp : 250mA
 - Isc : 270mA
 - PSTC : 1W
2) Halogen Lamp module: 1ea
 - One-touch clamp in two mountable positions
 - Adjustable angle: Up / down
 - Halogen Lamp (Circular type with a switch)
 - 220V 20W

ELECTRICITY METER MODULE (OP5)

1) Single-phase 2-wire (1P2W)
2) Load capacity: 220V, 6.6kW
3) Maximum current: 30A
4) Test current: 10A
5) Voltage : 220V 60Hz
6) Power loss : 3.7 / 0.42(VA)
7) Error : ±2%
8) Dimension: 250(W) x 120(D) x 309(H) mm

MAXIMUM POWER POINT TRACKING (MPPT) MODULE (OP6)

1) Graphical visualization: MPPT Schematic diagram (V-P and V-I characteristics)
2) Self-tracking function by the fluctuation of solar cell voltage
3) DC ampere meter : 2ea
4) DC voltmeter : 2ea
5) DC watt meter : 2ea
6) Solar cell input : 2ea
7) DC load (25W) : 2ea
8) Dimension: 380(W) x 120(D) x 309(H) mm

DC METER MODULE (OP8)

1) DC voltmeter: 1ea
2) DC ampere meter: 1ea
3) Voltage input terminal: 2ea
4) Current input terminal: 2ea
5) Dimension: 124(W) x 120(D) x 309(H) mm

ANALOG WATT HOUR METER MODULE (OP9)

1) Function: Real-time power consumption monitoring
2) Rotation:
   Forward rotation at the time of power consumption
   Reverse rotation upon transmitting the generated power
3) Power source : Single-phase 2-wire
4) Wiring connection : Up and down / left and right
5) Rated voltage : 220V 60Hz
6) I/O ON/OFF switch: 2sets
7) Insulated I/O terminal (4mm): 2sets
8) AC power inlet: 1ea
9) Output outlet : 1ea
10) Dimension: 380(W) x 120(D) x 309(H) mm

300W GRID CONNECTED INVERTER MODULE (OP10)

1) Rated input: 10.8V ~ 30V
2) Rated output: 270W (AC 220V 60Hz)
3) Maximum output: 300W (AC 220V 60Hz)
4) Inverter power level display: 4 steps
5) Import watt-hour meter: 1ea
6) Export watt-hour meter: 1ea
7) AC power line ELCB (AC220V 60Hz, 15A / 15mA): 1ea
8) AC load circuit ELCB (AC220V 60H, 15A / 15mA): 1ea
9) DC ON/OFF circuit breaker: 1ea
10) Insulated DC input terminal (4mm): 1set
11) AC power line inlet (grid connection) : 1ea
12) AC load outlet (AC 220V 60Hz) : 1ea
13) Insulated AC output terminal (4mm) : 1set
14) Dimension: 380(W) x 120(D) x 309(H) mm

STANDARD ACCESORRIES

- AC Power cord : 1set
- Connection cable (insulation type) : 1set
- Power supply cable for modules (round type 3/4pin) : 1set
- RS485 communication cable : 1set
- User's manual & experimental manual : 1set

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Installation Site References

<Gyeonggi College of Science and Technology>

<New Technology Training Center of Korea Polytechnic>

<Gwangju campus of Korea Polytechnic Ⅴ>

<Seoul Gangseo campus of Korea Polytechnic Ⅰ>

<Hongseong campus of Korea Polytechnic Ⅳ>

<Korea University of Technology and Education>