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Doc. No. : HHIS-WZ-PE-074 (00)

HPC-050HT/100HT Photovoltaic Inverter Manual

HYUNDAI
HEAVY INDUSTRIES CO.,LTD.

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1. Safety Instructions

The following 3 types of safety warnings are used:

⚠ DANGER

DANGER indicates a hazardous situation which, if not avoided, will result in serious injury or death! please follow the safety instructions of **DANGER**.

⚠ CAUTION

CAUTION indicates a hazardous situation which, if not avoided, could result in minor or moderate injury. It could also result in serious injury or death, please follow the safety instructions of **CAUTION**.

NOTICE

NOTICE indicates an important instruction. Please be noticed about the instructions of **NOTICE**.

1.1. Safety Instructions for Installation and Move

⚠ CAUTION

- Refer '**3. Installation and Wiring**' for installation and movement of the equipment.
- Keep the equipment out of flammable materials. It may induce fire.
- Hard ground which can firmly support the equipment should be secured for installation. (Refer '**3. Installation and Wiring**')
- Do not install damaged equipment. It may induce accidents.
- Environments of high temperature, high humidity, high condensation, dust, direct ray of sun, erosive gas, flammable gas, and explosive gas should be avoided. It may induce fire.
- The equipment should be installed inside a building with a good ventilation conditions.

1.2. Safety Instructions for Wiring

⚠ DANGER

- High-voltage power supply is connected to the equipment. Pay close attention to all the wiring instructions in this manual. Arbitrary wiring may induce electric shock and fire.
- Ground should be connected to the equipment. Ungrounded equipment may induce electric shock and fire.
- Wiring should be done by a professional electrician.
- Power switches of DC and AC panel should be off before wiring. When those switches are ON, shock and fire may be induced.
- Installation should be done before wiring. Incomplete installation of the equipment may induce electric shock and fire while wiring.

⚠ CAUTION

- DC rated voltage and AC supply voltage of the equipment should be complied with the equipment's specification. DC rated voltage and AC supply voltage those are not complied with the specification may induce electric shock and fire.
- DC power should not be connected to the output terminals(R, S, and T). When they are connected, fire may be induced.
- AC power should not be connected to the DC terminals (DC(+), DC(-)). When they are connected, fire may be induced.
- Loose bolt in the equipment should be avoided. It may induce fire.

1.3. Safety Instructions for Operation and Control

⚠ DANGER

- Do not to touch terminals inside the equipment. Do not detach wires and connectors to check signals while running. It may cause electric shock and fire.
- Be sure to turn the equipment on after closing the outside door. Do not open the outside door while running. It may cause electric shock.
- Do not touch the equipment with the wet hand. Touching PCS with wet hand may cause electric shock.
- Do not try to fix the equipment immediately on your own accord when the fault detecting light LED is on. The PCS automatically restarts after detecting fault. (Refer '**6. Faults and Solutions**')
- Do not put sticks or conductors inside PCS while running. They may cause electric shock and fire.

⚠ CAUTION

- Cooling fan is spinning while running. Do not touch upper side of the equipment where the fan is exposed. It may cause accidents.
- Follow the stopping and starting operational procedures when stop and start PCS.
- PCS may repeat ON and OFF because of low light capacity in the early morning and the early evening.

1.4. Safety Instructions for Maintenance

⚠ DANGER

- Wait for 30 minutes after turning off the DC circuit breaker in the DC panel and the AC circuit breaker in the AC panel to start maintenance work. Not enough wait may cause electric shock.
- Detach the metallic accessories such as watches and rings before maintenance.
- Use insulated tools.
- Maintenance should be done by designated personnel. Maintenance by not-authorized personnel may cause electric shock or accidents.

1.5. Safety Instruction for use

⚠ DANGER

- Do not modify the equipment. It may cause electric shock or accidents.

2. Overview

2.1. Checklist

2.1.1. Unit check

Check the followings before wiring and installing work for the unit:
(1) Is the unit damaged while transporting?
(2) Are a PCS unit and a manual included?
(3) Are the specifications of type plates (Figure 2.3, Figure 2.4) and the ordered specifications are agreed?

Figure 2.1 HPC-050HT Exterior

Figure 2.2 HPC-100HT Exterior

HYUNDAI HEAVY INDUSTRIES CO., LTD.
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태양광발전용 계통연계형 인버터
Grid-tied Photovoltaic Inverter
Service Center : (82)-52-202-8445/6

모델명 (Model Name)		HPC-050HT	
입력사양 (Input Data)		출력사양 (Output Data)	
MPPT 전압범위 (MPPT Range)	300-600Vdc	정격용량 (Nominal Output Power)	50kW
최대입력전압 (Max. Input Voltage)	650Vdc	정격계통전압 (Nominal Grid Voltage)	3PH 380Vac
정격입력전압 (Rated Input Voltage)	450Vdc	정격계통주파수 (Nominal Grid Frequency)	60Hz
제조년월 및 번호 (Mfg Date & No.)			

Figure 2.3 HPC-050HT Type Plate

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Service Center : (82)-52-202-8445/6

모델명 (Model Name)		HPC-100HT	
입력사양 (Input Data)		출력사양 (Output Data)	
MPPT 전압범위 (MPPT Range)	300-600Vdc	정격용량 (Nominal Output Power)	100kW
최대입력전압 (Max. Input Voltage)	650Vdc	정격계통전압 (Nominal Grid Voltage)	3PH 380Vac
정격입력전압 (Rated Input Voltage)	450Vdc	정격계통주파수 (Nominal Grid Frequency)	60Hz
제조년월 및 번호 (Mfg Date & No.)			

Figure 2.4 HPC-100HT Type Plate

2.1.2. Manual

Read the manual before installing HPC-050HT and HPC-100HT. And keep the manual around the unit for correct operation and maintenance. Manual must be delivered to the unit operator.

2.2. Inquiry and Warranty

2.2.1. Inquiry

Please contact the manufacturer with the following information of the damaged PCS, the unknown parts and the others.
(1) PCS model
(2) Manufacturing No.
(3) Date of purchasing
(4) Contents :
- Information of the damaged parts.
- Information of the unknown parts.

2.2.2. Warranty

Three-year limited warranty is guaranteed except the cases of the following. Extra cost will be charged to the user for the following cases.
(1) Incorrect operation, inadequate repair, and modification.
(2) External reasons.
(3) Use out of the specifications.
(4) Nature disasters (Earthquake, Lightning, etc.)

Warranty is limited to the PCS unit itself. Warranty does not include the recovery of any secondary damage induced by the breakdown of the PCS.

After the free warranty period, tests and repairs will be charged.

Contact the manufacturer for warranty related matters.

2.3. Dimension

Dimensions of HPC-050HT and HPC-100HT are shown in figure 2.5 and figure 2.6. Display device, Door handle and air intake filter for cooling fan are located in front door. Covers for air discharging of cooling fan are located on the upper side.

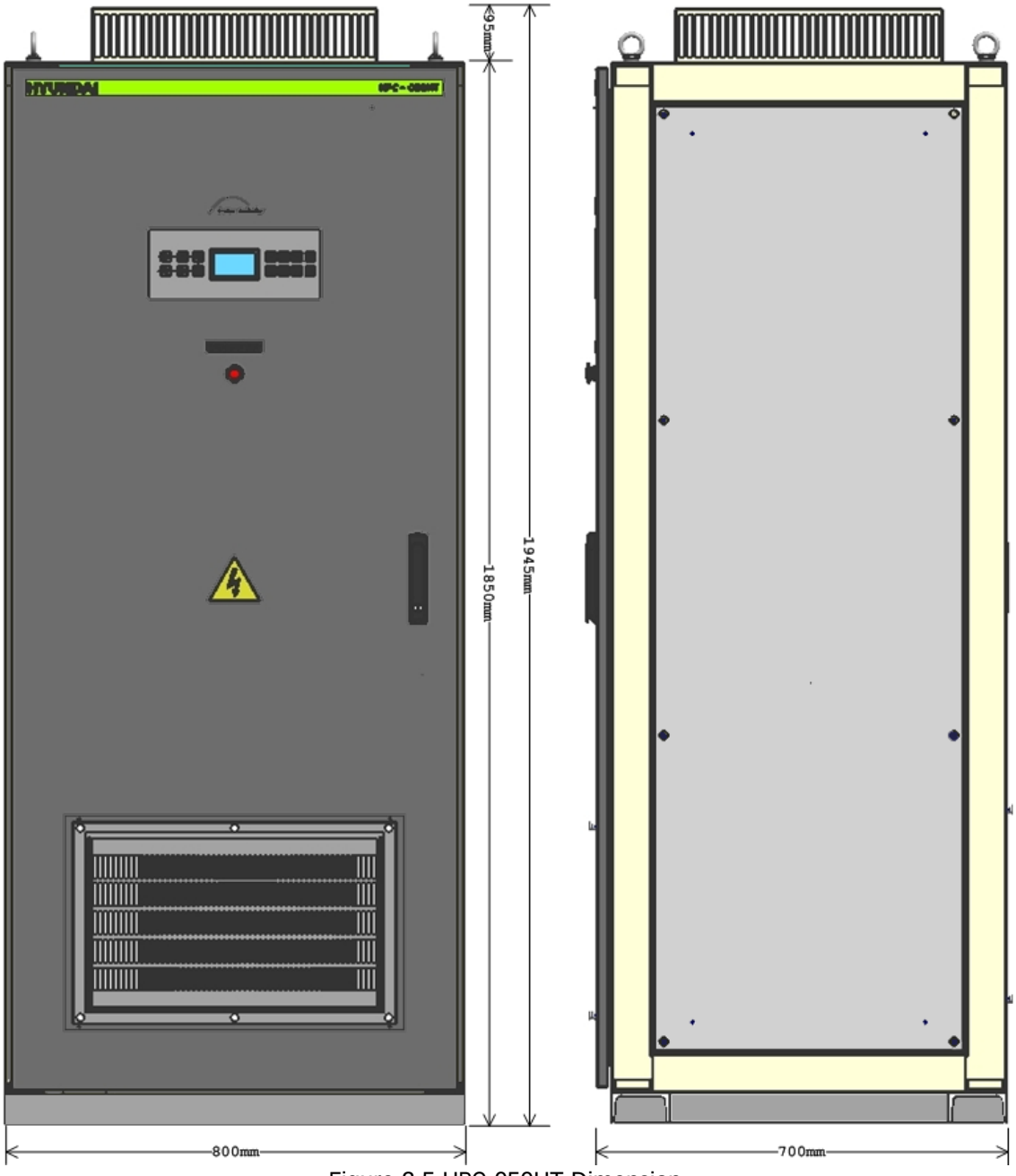


Figure 2.5 HPC-050HT Dimension

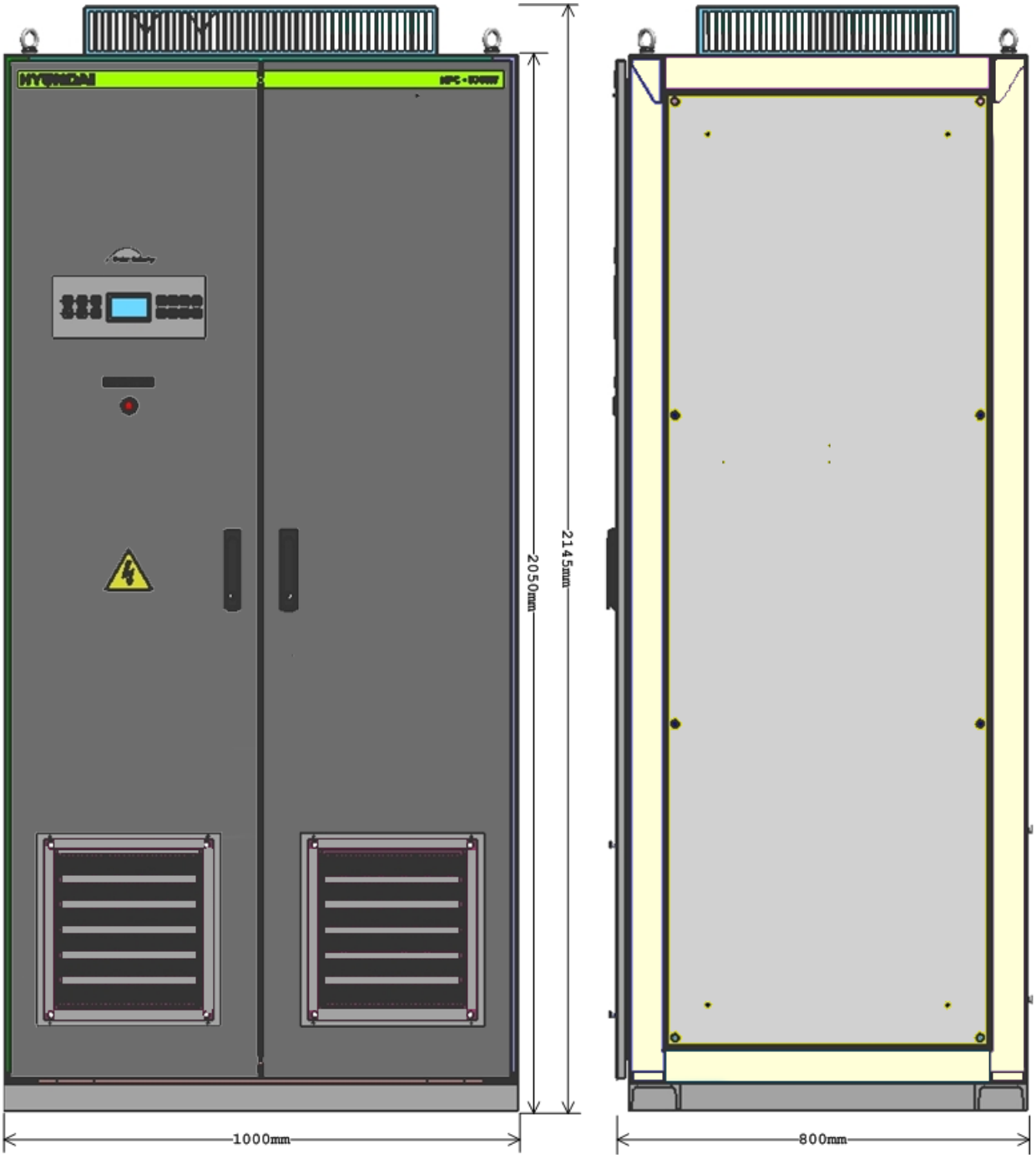


Figure 2.6 HPC-100HT Dimension

3. Installation and Wiring

⚠ DANGER

- High voltage supply is connected to the unit. Follow the manual when wiring. Incorrect wiring may cause electric shock or fire.
- Be sure to connect ground line to the unit. The unit without ground connection may cause electric shock or fire.
- Wiring should be done by a professional electrician. Wiring by unauthorized personnel may cause electric shock or fire.
- Power supply switches of DC and AC panel should be OFF before wiring. Supplying power while wiring may cause electric shock or fire.
- Be sure to wire after installing the unit to the proper location. Unfinished and unstable installation may cause electric shock or fire.

⚠ CAUTION

- Check the agreement of DC rated voltage and AC supply voltage with the unit specifications. Disagreement of those voltages may induce accident or fire.
- Do not connect DC power to the output terminals(R, S, and T). It may cause fire.
- Do not connect AC power to the DC terminals (DC(+), DC(-)). It may cause fire.
- Check for loose bolts. It may cause fire.

3.1. Installation

Requirements of Electrical specifications (for Grid and Photovoltaic array) and installing location for HPC-050HT and HPC-100HT are as follows.

3.1.1. Grid Requirements

	HPC-050HT	HPC-100HT
Incoming Capacity	≥ 50kVA	≥ 100kVA
Incoming Voltage	3-phase, 380 Vac (-12% ~ +10%) 60Hz (59.3 Hz ~ 60.5 Hz)	

Table 3.1 HPC-050HT/100HT Grid Requirements

3.1.2. PV Input Requirements

	HPC-050HT	HPC-100HT
MPPT Range	300 ~ 600Vdc	
Max. Open Circuit Voltage	650Vdc	
Max. Input Current	175Adc	350Adc

Table 3.2 HPC-050HT/100HT Input Requirements

3.1.3. Requirements for Installation

	HPC-050HT	HPC-100HT
Size (mm^3)	800 X 700 X 1945 mm^3	1000 X 800 X 2145 mm^3
Weight (Kg)	790kg	1230kg
Ambient Temp.	-10 ~ 40 °C	
Storing Temp.	-10 ~ 50 °C	
Relative Humidity	≤95%	≤95%
Altitude	≤2000m	≤2000m

Table 3.3 HPC-050HT/100HT Installation Requirements

3.1.4. Ventilation

HPC-050HT and HPC-100HT need at least 500mm vacant spaces of each front and rear side for ventilation.

3.1.5. Auxiliary Power

HPC-050HT and HPC-100HT use following auxiliary power as control power:

- Rated Voltage: 220 Vac ±10%
- Max. Power : 300 W

A single phase in 3-phase output power can be used as a control power without any auxiliary power. In this case, contact A/S center.

3.1.6. Communication port

RS-485 communication port is located on SI-DCP board which is at the back side of left door. (CN4 is the communication port.) TR+ and TR- are allocated to the pin no.3 and no.6 of RJ-45 socket in CN4. UTP cabling should be done as follows.

1. Detatch the cover for SI-DCP board which is located at the back side of left door. (refer figure 3.1)

Figure 3.1 SI-DCP Board Cover

2. Connect UTP cable to CN4 port on SI-DCP board. (refer figure 3.2)

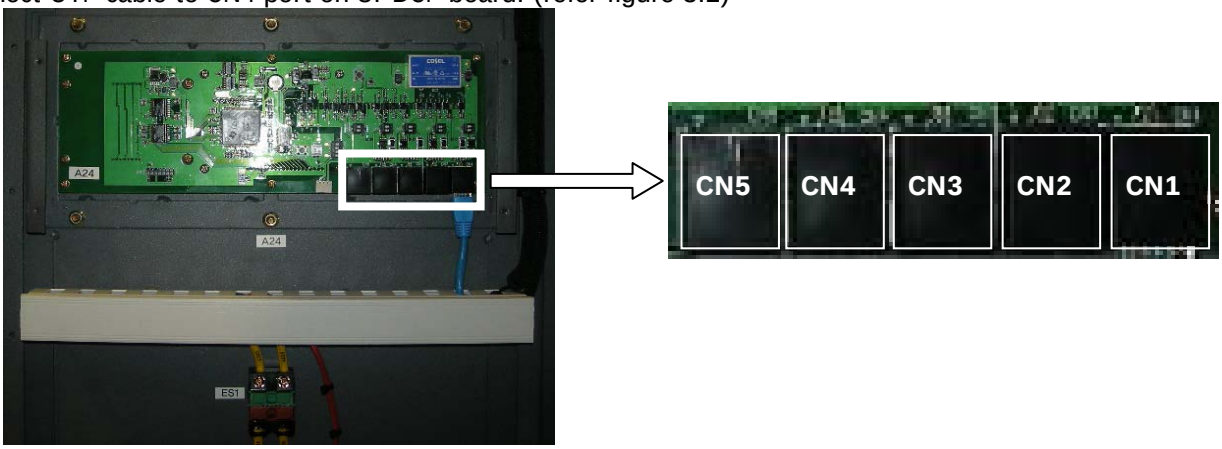


Figure 3.2 Communication Ports

Cable should be made by considering TX+ and TX- are allocated to the pin no.3 and no.6 of RJ-45 socket in CN4.

3.2. Wiring

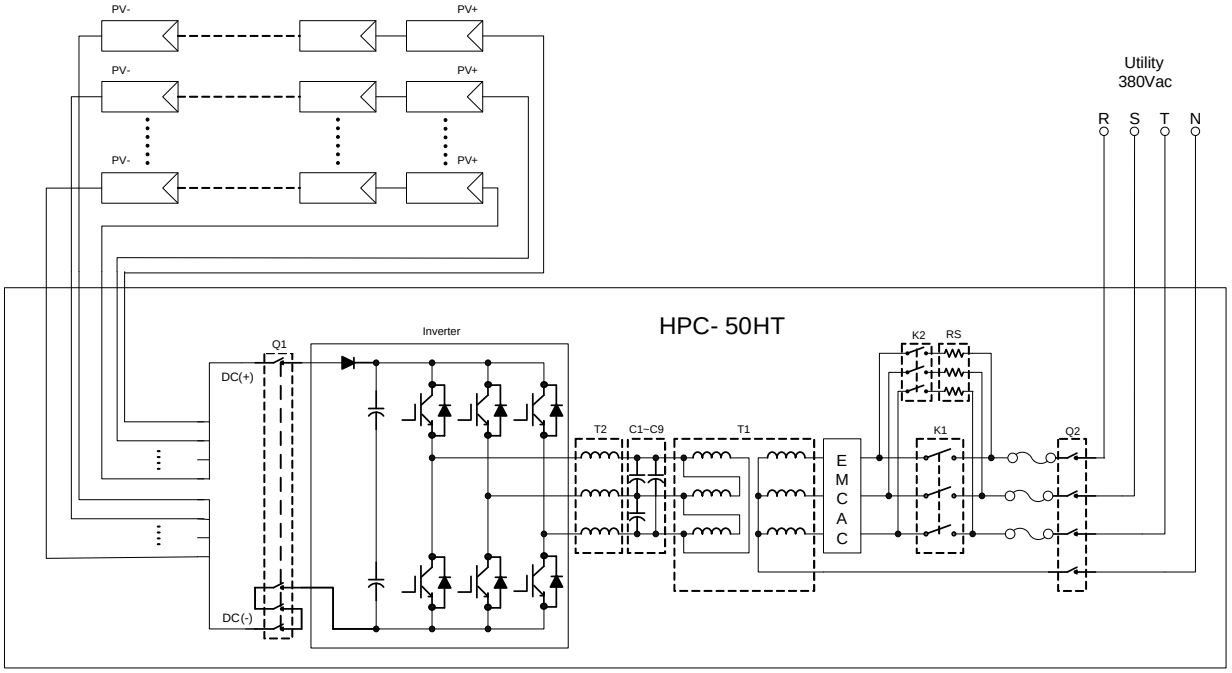


Figure 3.3 HPC-050HT Wiring

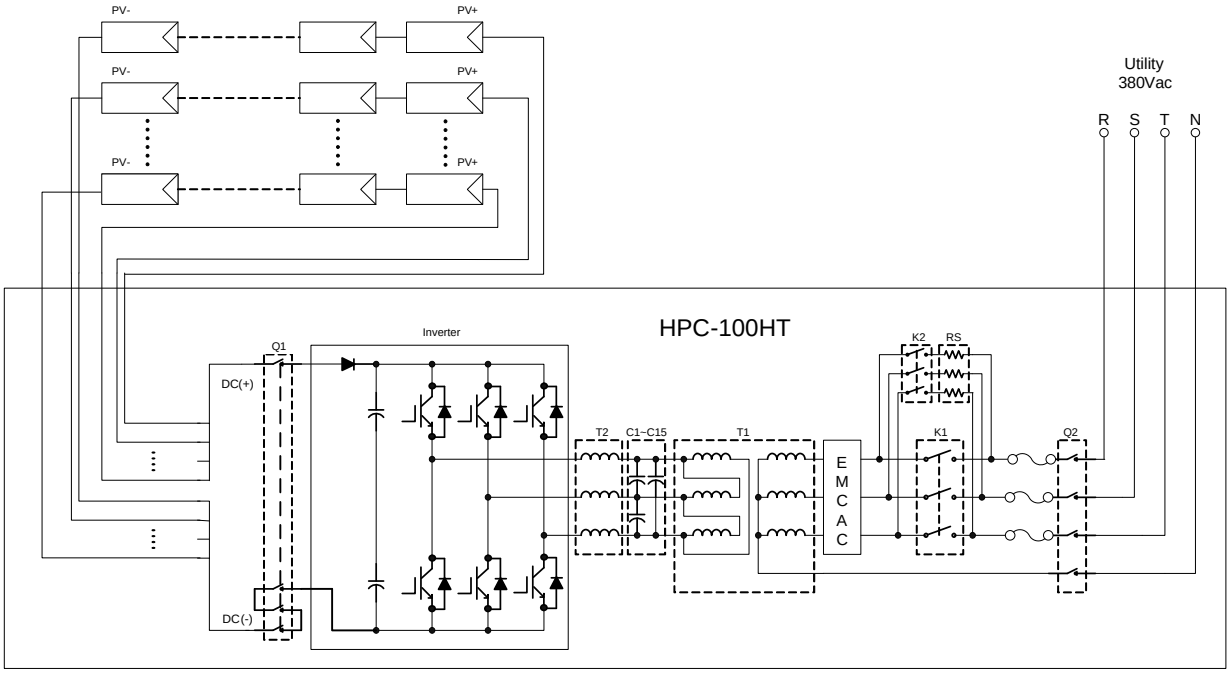


Figure 3.4 HPC-100HT Wiring

When the PCS is initially installed, follow the wiring steps as below.

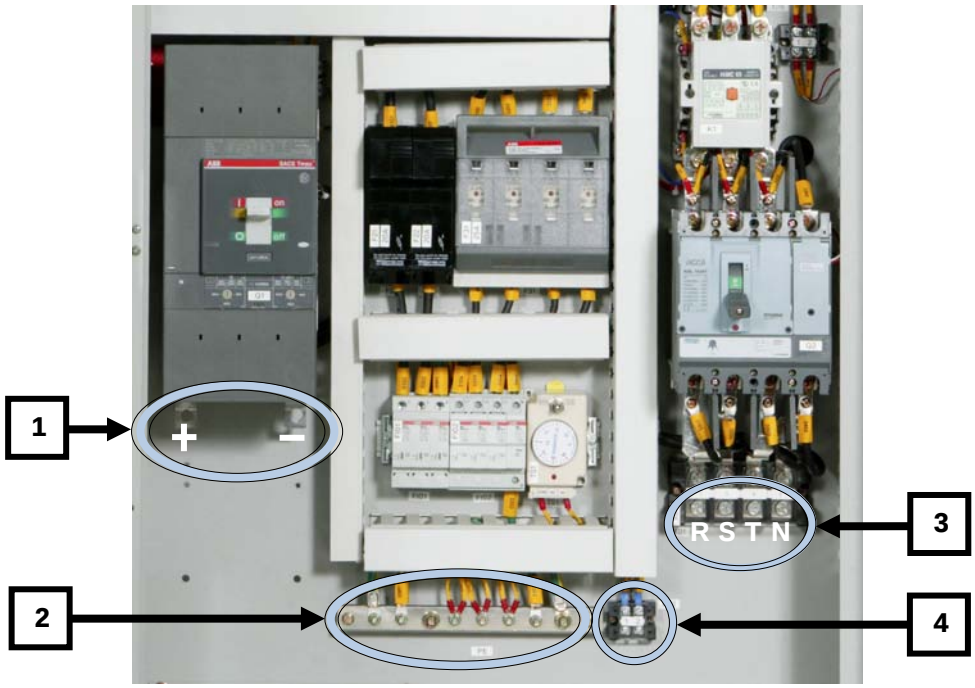
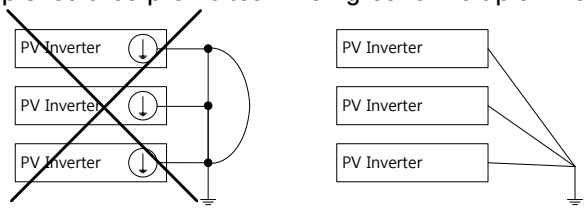


Figure 3.5 HPC-050HT Front Inside

Figure 3.5 shows front inside part of HPC-050HT (50kW model). Details for wiring are as follows:

1 : Connect DC power line (DC power line from string box). Connect DC(+) line to the left terminal and DC(-) line to the right terminal by considering terminal hole size (M10).

2 : Connect ground line. Loop should be prohibited when ground multiple inverters.



3 : Connect grid power line(AC 380V, three-phase four-wire). Terminals of R-phase, S-phase, T-phase, and Neutral are aligned orderly from left. Please connect grid power line by considering hole size(M8) and phase order.

4 : Connect control power line(AC 220V, single-phase). Any phase order is allowed for the connection.

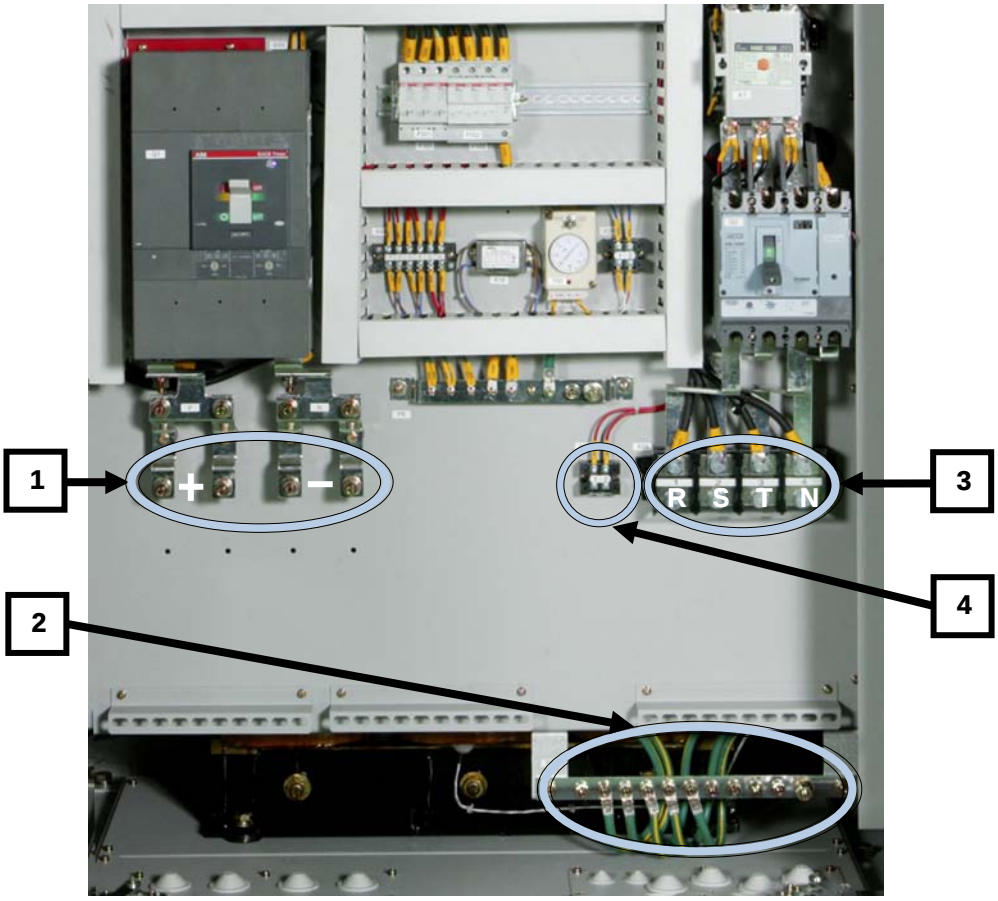
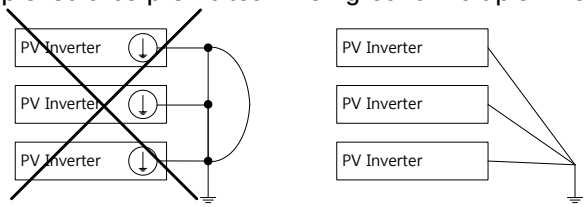


Figure 3.6 HPC-100HT Front Inside

Figure 3.6 shows front inside part of HPC-050HT (50kW model). Details for wiring are as follows:

1 : Connect DC power line (DC power line from string box). Connect DC(+) line to the left terminal and DC(-) line to the right terminal by considering terminal hole size (M10).

2 : Connect ground line. Loop should be prohibited when ground multiple inverters.



3 : Connect grid power line(AC 380V, three-phase four-wire). Terminals of R-phase, S-phase, T-phase, and Neutral are aligned orderly from left. Please connect grid power line by considering hole size(M8) and phase order.

4 : Connect control power line(AC 220V, single-phase). Any phase order is allowed for the connection.

4. Features

4.1. Features

HPC-050HT and HPC-100HT are 50kW and 100kW grid tied photovoltaic PCS (Power Conditioning System).

- **Flexible Module Structuring**
  When photovoltaic modules are structured in the form of a central type, high voltage (up to 650V) also can be used as input. MPPT range is from 300V to 600V.

- **MPPT (Max Power Point Tracker) Control**
  Solar Cell generates power in accordance with the surrounding environments such as ambient temperature and the intensity of light. So the PCS system should have capability of controlling the working point of the solar cells to get maximum power. HPC-050HT and HPC-100HT controls the working point of the solar cells and takes maximum powers from them.

- **High Power-Factor and High-Efficiency**
  HPC-050HT and HPC-100HT controls the power factor and keeps it staying above the value of 0.99 so that they can supply stable power and reduce the side effects, such as damage from harmonics, to the connected electrical equipments.
  HPC-050HT and HPC-100HT also achieve high system efficiency (95% and above) by adopting a high efficient power conversion design.

- **System Monitoring and Self Diagnosis**
  HPC-050HT and HPC-100HT are automatically run by controlling and monitoring the system using digital controller. When system faults are detected, self-protection function stops the system to generate power and then displays the faults information on the LCD screen of SI-DCP so that the operator can recognize the fault information.

- **Remote Monitoring**
  HPC-050HT and HPC-100HT support RS-485 communication protocol so that operators can remotely monitor the power generation status of the system.

4.2. Specifications

	ITEM	HPC-050HT	HPC-100HT	NOTES
INPUT	Max. DC voltage	650Vdc		
	MPPT range	300Vdc ~ 600Vdc		
	Max. input current	175Adc	350Adc	
OUTPUT	Number of phases	3-phase 4-wire		
	Nominal AC output	50kW	100kW	
	Nominal output voltage	380Vac (+10%, -12%)		
	Operating Frequency	60Hz		
	THD of AC current	≤ 5%		with Rated load
	Power factor	≥ 0.99		with Rated load
OPERATION	Inverter controlling method	PWM		
	Output operational method	Grid-tied type		
	Input controlling method	MPPT		
SPECIFICATION	European efficiency	≥ 95%		
	Cooling method	Air cooling (fan)		
	Display	Graphic LCD		
	Communication interface	RS-485		
	Ambient temperature	-10~40℃		
	Relative humidity	0~95%, non condensing		
	Protection	■ Input under/over voltage detection ■ Grid under/over voltage detection ■ Grid under/over frequency detection ■ Output over current detection ■ Avoid island operation ■ System over-temperature detection		
	Dimension (mm^3)	800 x 700 x 1945	1000 x 800 x 2145	W x D x H

Table 4.1 HPC-050HT/100HT Specifications

4.3. HPC-050HT/100HT Block Diagram

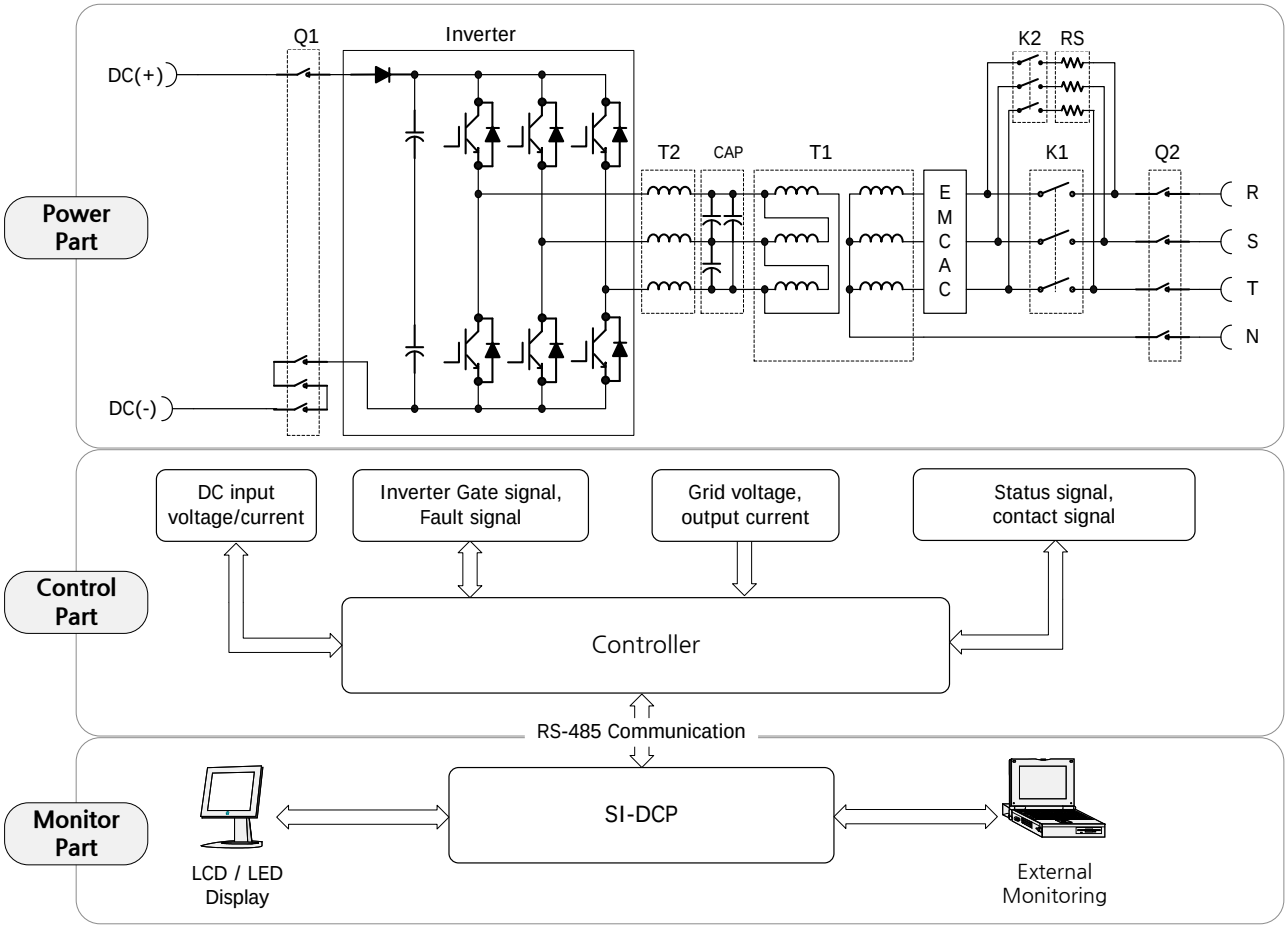


Figure 4.1 HPC-050HT/100HT Block Diagram

The block diagram of PV power generating system is shown in figure 4.1. The system can be grouped to 3 parts power, control, and monitor part.

Power part is consisted of
- Circuit breaker which is connected to PV array
- LC filter which connects inverter circuit to the 3-phase grid line
- 3-phase transformer for insulation
- Noise filter circuit
- Pre-charge limiting circuit
- Circuit breaker

Control part is consisted of
- Main Control Unit
- Interface board

This part provides the controlling functions for power generation and the system protecting functions.

Monitor part is consisted of
- SI-DCP
- External displaying devices

This part displays system information, parameter information, and fault event information.

4.4. Controller Block Diagram

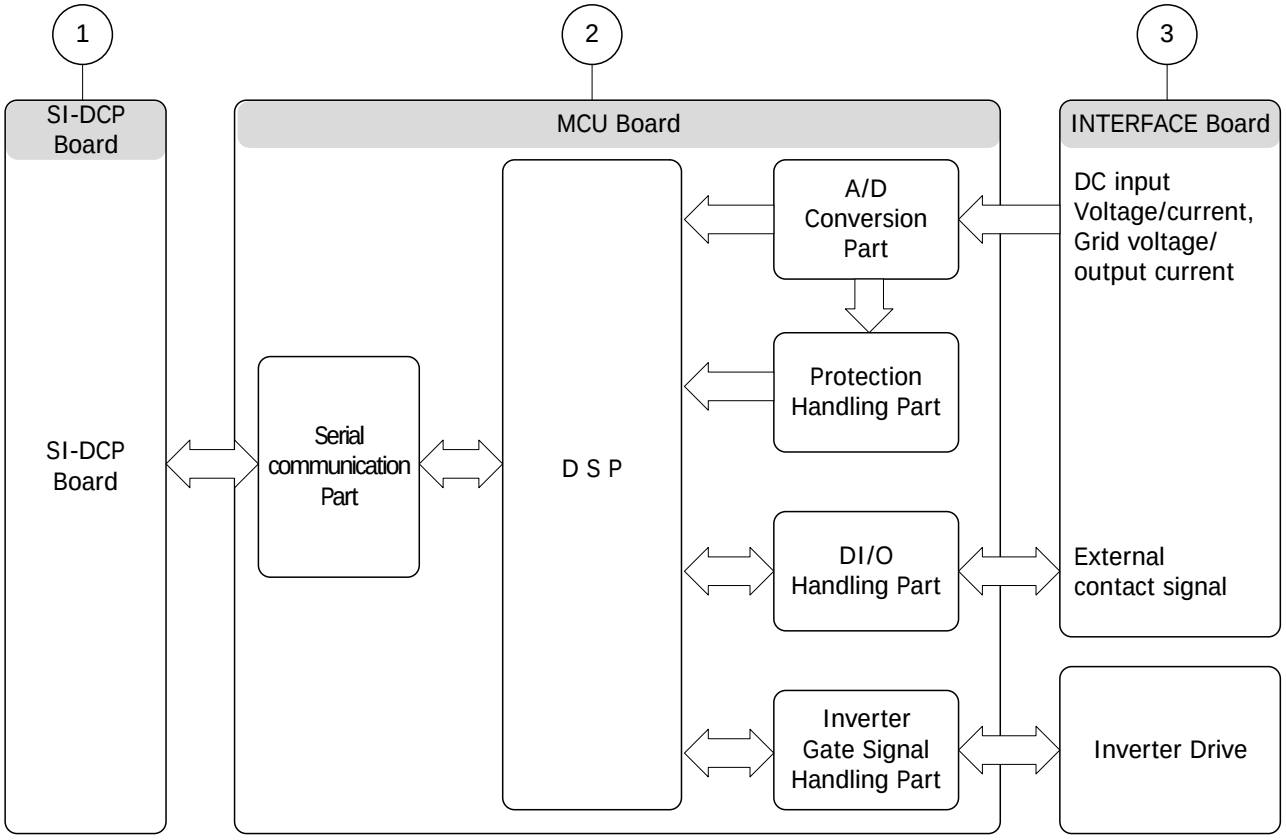


Figure 4.2 Controller Block Diagram

No.	Device	Functions	Notes
1	SI-DCP board	– Displays internal information – Sets parameters (Time, MPP, etc.) – Stores fault event history – Supports inverter to communicate with the external monitoring devices (support RS-485 protocol)	
2	MCU board	– Supports A/D conversion – Controls MPPT – Controls Power factor – Controls inverter starting and stopping functions – Supports automatic fault-stopping and fault-handling	
3	Interface board	– Detects DC voltage/current – Detects grid voltage/current – Delivers various external contact signals – Runs external relay	

Table 4.2 Functions of Controller Boards

5. Operation

⚠ DANGER

- Do not touch terminals inside PCS and do not detach wires and connectors from PCS while running. They may cause electric shock and fire.
- Turn on the external circuit breaker for PCS power supply after closing the case door.
- Do not open the case door while running. It may cause electric shock.
- Do not touch the PCS with wet hand. It may cause electric shock.
- Do not touch the terminals of PCS while running or stopping. It may cause electric shock.
- Do not put any sticks or substances into the PCS system. It may cause electric shock and fire.

⚠ CAUTION

- Do not touch the top side of the PCS. Cooling fan is spinning on top side of the PCS. It may cause accidents.
- Follow the starting and stopping procedure of the manual when you start or stop PCS.
- PCS may repeat ON and OFF in the early morning or evening because of the low intensity of the light.

5.1. Control Part

PCS is starting its operation when the DC circuit breaker (Q1), AC circuit breaker (Q2) are on and the case door is closed. The part names and locations of control part of HPC-050HT/100HT are as follows:

5.1.1. DC (PV Module) (Q1) : DC circuit breaker

DC circuit breaker (Q1) connects or disconnects DC power from PV array to HPC-050HT/HPC-100HT. After finishing installation, HPC-050HT/HPC-100HT will start its operation only when the case door is closed and this circuit breaker is turned on.

5.1.2. AC (Grid) (Q2) : AC circuit breaker

AC circuit breaker (Q2) connects HPC-050HT/HPC-100HT to the grid or disconnects HPC-050HT/HPC-100HT from the grid. This circuit breaker must be turned on to start PCS operation.

5.1.3. Circuit breakers for control power (Q3, Q4)

Circuit breakers for control power(Q3, Q4) supply or stop supplying control power to HPC-050HT/HPC-100HT. These circuit breakers must be turned on to start PCS operation.

5.1.4. Limit Switch (LS1)

Limit switch (LS1) protects PCS from starting its operation while the case door is opened. When the door is opened or not correctly closed, this switch turns on the light inside the case and stops PCS operation.

5.1.5. Emergency Switch (ES)

Emergency switch (ES) disconnects PCS from the grid immediately. This switch is used in the emergency situations.
NOTICE) If too much strength were forced into this switch, the switch would be broken.

5.1.6. SI-DCP (A24)

The status of the PCS system is displayed on the SI-DCP which is located at front side. And the system parameters can be set through SI-DCP. The stored fault history of the system is also shown through SI-DCP.

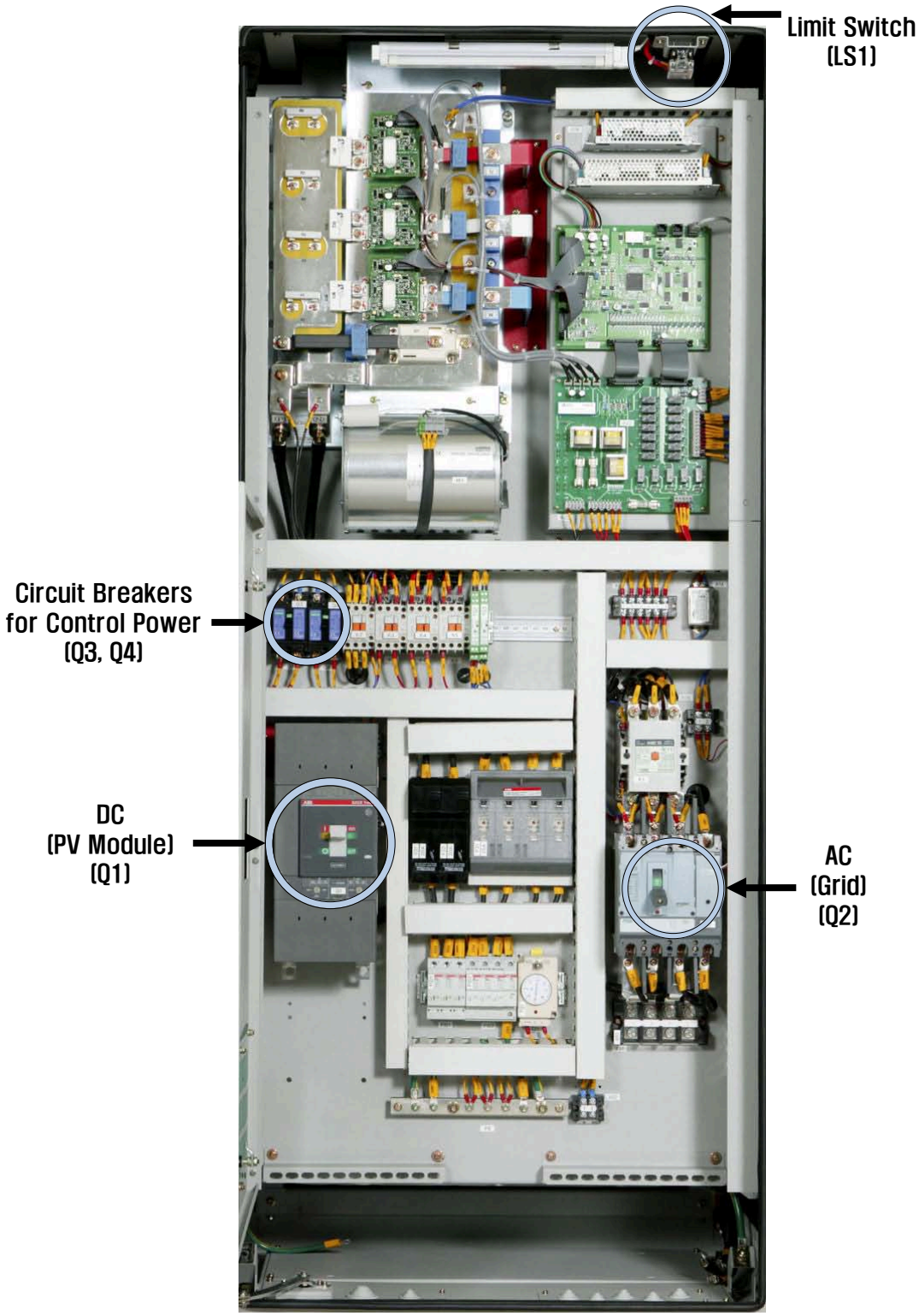


Figure 5.1 HPC-050HT Inside Panel

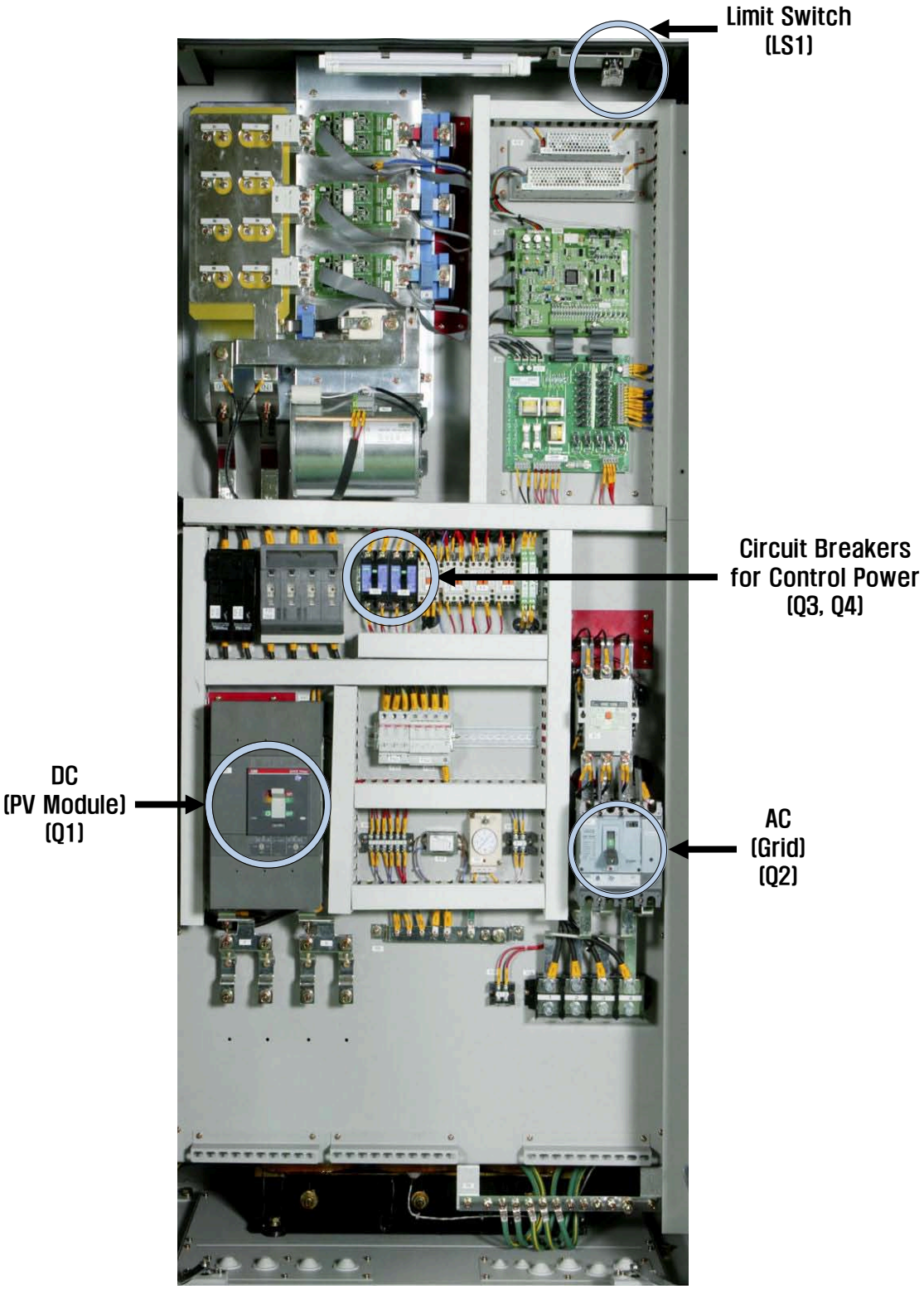


Figure 5.2 HPC-100HT Inside Panel

5.2. Starting Procedure

Follow the steps below to start the PCS system. PCS system may be broken when the starting steps are not followed correctly. The installation diagram of PCS for PV power generating is shown in figure 5.3.

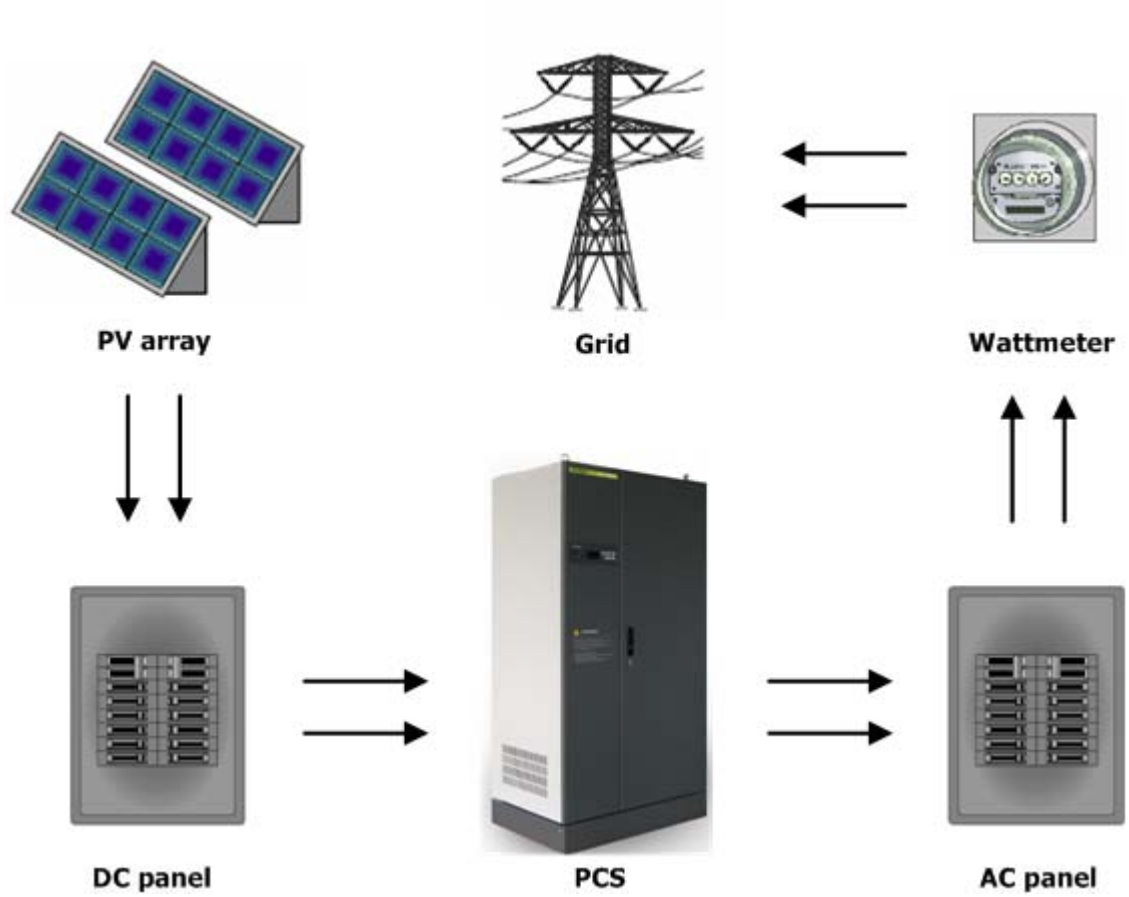


Figure 5.3 PCS installation diagram for PV power generation

5.2.1. Connecting AC and DC Power Lines

(1) Open the case door.

(2) Connect single-phase 220V AC power line to **X02** terminal.

(3) Measure the output voltage of the PV array and the voltage of the 3-phase AC grid before connecting them to the input terminal block and output terminal block. The measured output voltage of the PV array should be equal or less than 650Vdc and the R-S, S-T, and T-R line voltages of the 3-phase AC grid should be 380V (-12% ~ +10%). If these requirements are not satisfied in the site, please contact the manufacturer.

(4) Connect the DC and 3-phase AC voltage power lines to the DC and AC terminal blocks. (+) and (-) in DC supply lines and 3-phase AC supply lines should be matched with the phase labels marked on the terminal block.

5.2.2. Starting Procedure

(1) Turn the circuit breakers Q3 and Q4 in AC panel on.
(2) Turn the circuit breakers Q1 in DC panel on.
(3) Turn the circuit breaker Q2 in AC panel on.
(4) Close the case door.
(5) After completing (1)-(4) steps, PCS will start its MPPT (MPP Tracking) function as shown in figure 5.4. And then it finishes its normal starting operation.

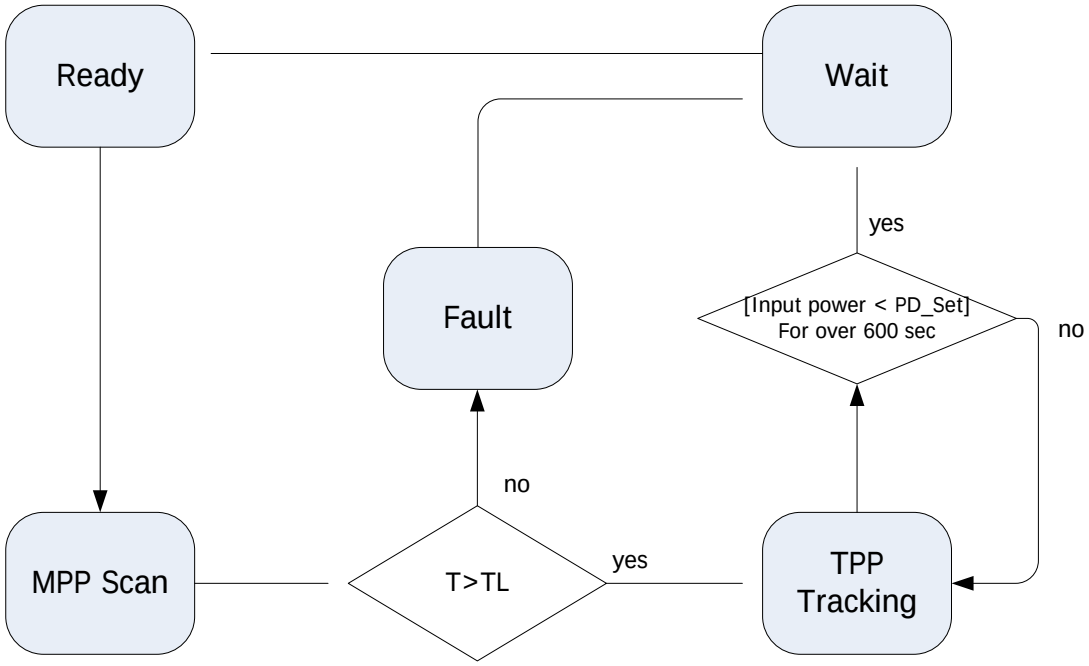


Figure 5.4 Max Power Point Tracking(MPPT) Process

5.3. Stopping procedure

The PCS system should be stopped as following steps.

(1) Choose one method out of 4 methods for stopping the system.
- Turn off the circuit breaker in DC panel.
- Turn off the circuit breaker in AC panel.
- Push 'STOP' button of SI-DCP on the front side.
- Push Emergency Stop button

(2) After the system is stopped by using a method of (1), please check that the cooling fan on top of the case stops in 1 minute.

(3) Turn off all the circuit breakers in DC and AC panel.

(4) Terminal blocks for PV array and grid connection should be completely discharged. If they are not, please wait until they are completely discharged.

5.4. SI-DCP Operator

SI-DCP operator in HPC-050HT/HPC-100HT is shown in figure 5.5. The system user can set various system parameters and see the status of the system through the operator.

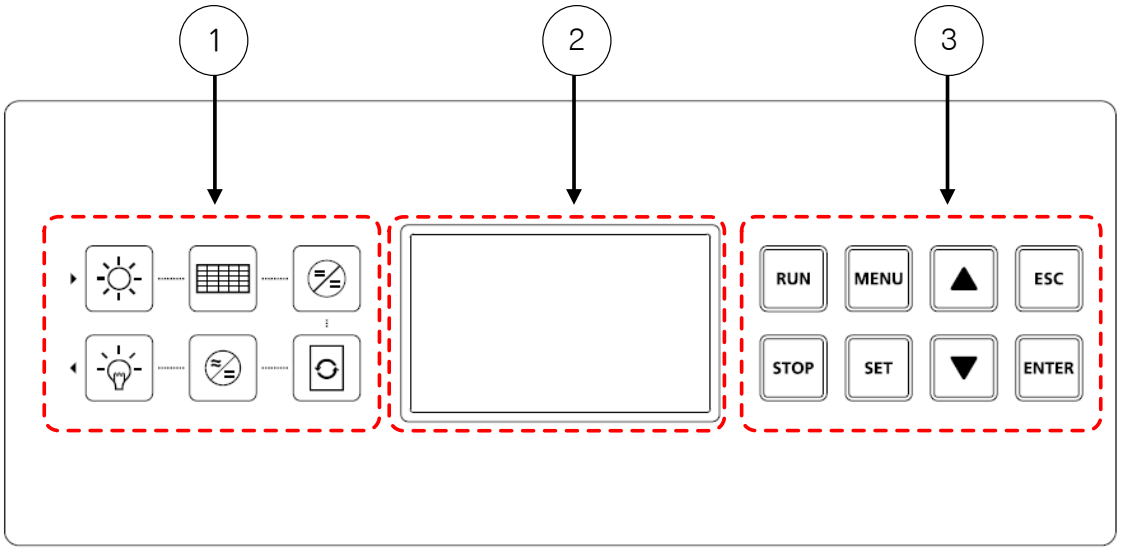


Figure 5.5 Operator of SI-DCP

The names of each part are as follows:

- LED part : Displaying PCS Status
- Graphic LCD part
- SI-DCP buttons

5.4.1. Graphic LCD Part

General information and parameter setup screen is shown in this part.

5.4.2. LED Part

Operating status of the PCS system is simply shown in this part. The descriptions of each item are as follows:

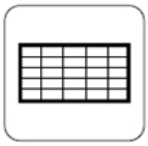
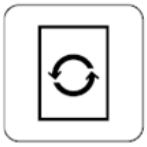
Item	Lighting condition	Normal status	notes
	DC MCCB is ON, Input voltage is normal. (300Vdc ~ 600Vdc)	LED ON	
			
			
	PCS starts its operation	LED ON	
	PCS generates over 1kW after its start.	LED ON	
			

Table 5.1 LED part description

5.4.3. SI-DCP Buttons

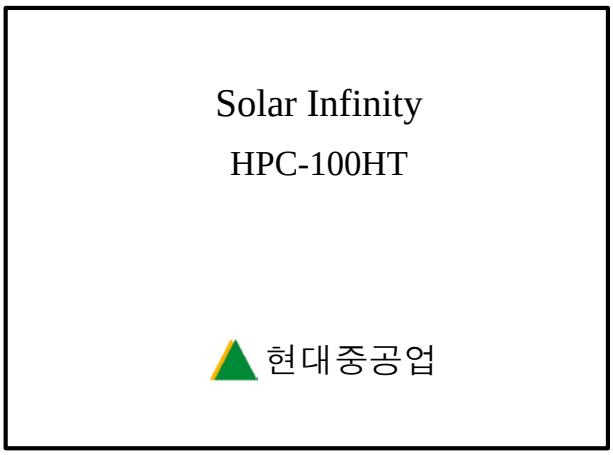
Item	Description	Notes
	■ Start the PCS system manually. ■ Use this button for starting manually stopped system.	
	■ Stop the PCS system manually. ■ Use this button for stopping the system manually.	
	■ Show menu screen. ■ Use this button for requesting screens of parameter setup, time setup, and faults history.	
	■ Confirm the set parameter values. ■ Confirm the set time values.	
	■ Move to upper menu item. ■ Increases value.	
	■ Move lower menu item. ■ Decreases value.	
	■ Cancel or stop current screen function ■ Return to main screen.	
	■ Select a menu. ■ Set the changing value. ■ Confirm the changing.	

Table 5.2 SI-DCP Buttons' Description

5.5. Graphic LCD Screens

5.5.1. Main Logo Screen

Main logo screen displays model type information as shown in figure 5.6. This screen is shown for 3 seconds after powered-on or controller reset. Select 'System info.' item in 5.5.10.5 to see detailed PCS information.



Screen 5.6 Main Logo Screen

5.5.2. PCS Input Screen

Input power, voltage, and current from the PV array are displayed in the [PCS INPUT] screen as shown in figure 5.7.

- P_{pv} : input power from the PV array.
- V_{pv} : input voltage from the PV array.
- I_{pv} : input current from the PV array.

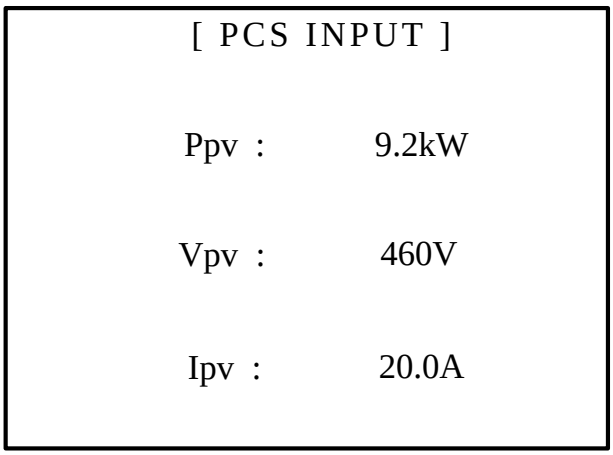


Figure 5.7 PCS input Screen

5.5.3. Grid Screen

Grid voltages and currents are displayed in the [Grid] screen as shown in figure 5.8.

- Grid[V]: Currently measured grid line voltages.
- Grid[I]: PCS output current.
- R, S, T: Phases of the grid.

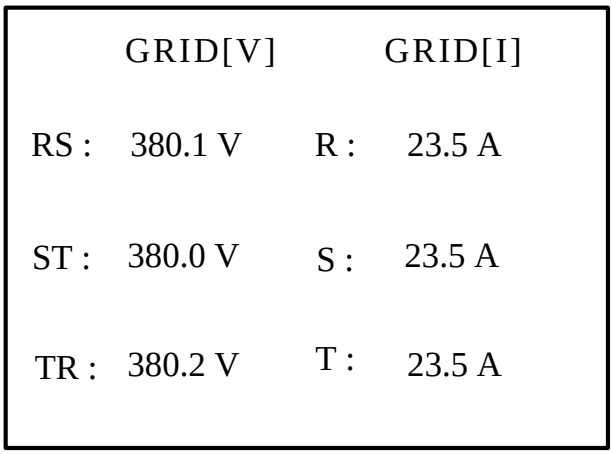


Figure 5.8 Grid Screen

5.5.4. PCS Output Screen

Information of the generated power through the equipment is displayed in [PCS OUTPUT] screen as show in figure 5.9.

- Pac : Current power output
- Pmax : Maximum power output of the day
- P.F : Power factor
- f : Grid power frequency

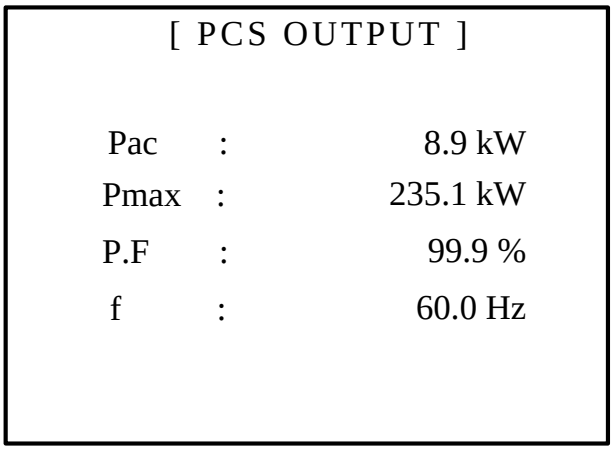


Figure 5.9 PCS Output Screen

5.5.5. Status Screen

Status information of PCS is displayed in [STATUS] screen as shown in figure 5.10.

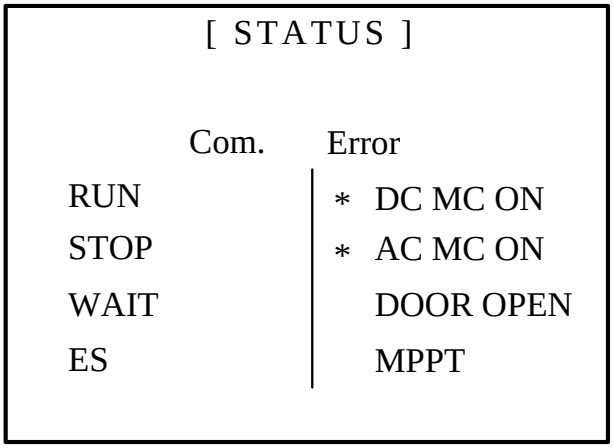


Figure 5.10 Status Screen

Descriptions of the items are as follows:

No.	Item	Description	Notes
1	Com. Error	Operational status of the PCS - RUN: running. - STOP: PCS is stopped running. - ES: PCS is stopped by 'Emergency Stop'. - WAIT: PCS is waiting for power generation.	
2	RUN	Major faults have detected. PCS cannot be run.	
3	STOP	Minor faults have detected.	
4	WAIT	Frequency of the grid voltage is OK.	
5	ES	Synchronization with the phases of the grid voltage is OK.	
6	DC MC ON	PCS output current is OK.	
7	AC MC ON	Input current is OK.	
8	DOOR OPEN	Grid voltage is OK.	
9	MPPT	Input voltage is OK.	

Table 5.3 Status Screen Item Description

5.5.6. Accumulated Data Screen

Accumulated data of PCS is shown in [ACCU. DATA] screen as shown in Figure 5.11.

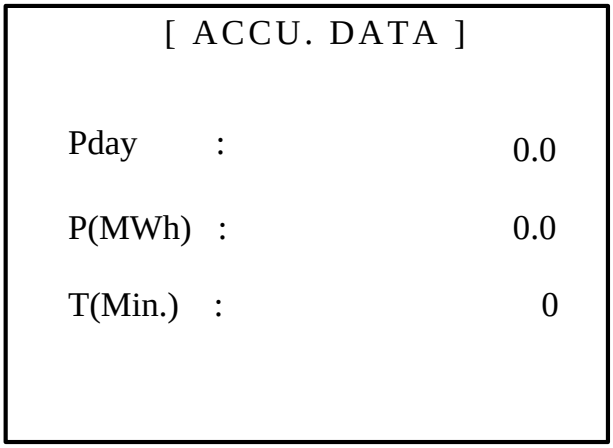


Figure 5.11 Accumulated Data Screen

Descriptions of the items are as follows:

No.	Item	Description	Remarks
1	Pday	Accumulated power output of the day (KWh)	
2	P(MWh)	Accumulated power output during PCS life time (MWh)	
3	T(Min.)	Accumulated power generation time during PCS life time	

Table 5.4 Accumulated Data Screen Item Description

5.5.7. S/W Fault Screen

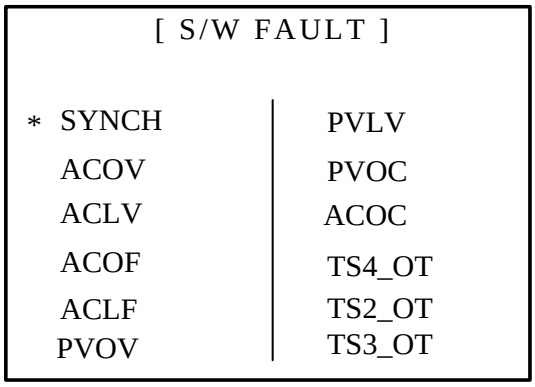


Figure 5.12 S/W Fault Screen

S/W fault information is shown in [S/W FAULT] screen as shown in figure 5.12. Descriptions of the items are as follows :

No.	Item	Description	Remarks
1	SYNCH	Frequency synchronization	
2	ACOV	Over voltage in grid(AC) side	
3	ACLV	Low voltage in grid(AC) side	
4	ACOF	Over frequency in grid(AC) side	
5	ACLF	Low frequency in grid(AC) side	
6	PVOV	Over voltage in PV(DC) side	
7	PVLV	Low voltage in PV(DC) side	
8	PVOC	Over current in PV(DC) side	
9	ACOC	Over current in grid(AC) side	
10	TS4_OT	Over temperature in Stack	
11	TS2_OT	Over temperature in output filtering reactor	
12	TS3_OT	Over temperature in output transformer	

Table 5.5 S/W Fault Screen Item Description

5.5.8. H/W Fault Screen 1

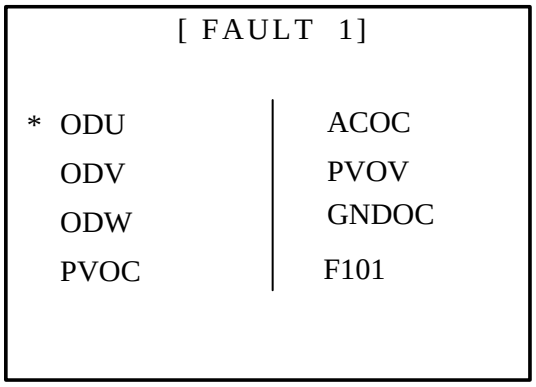


Figure 5.13 H/W Fault 1 Screen

H/W fault information 1 is shown in [FAULT 1] screen as shown in figure 5.13. Descriptions of the items are as follows :

No.	Item	Description	Remarks
1	ODU	Stack fault in U-phase	
2	ODV	Stack fault in V-phase	
3	ODW	Stack fault in W-phase	
4	PVOC	Over current in PV(DC) side	
5	ACOC	Over current in grid(AC) side	
6	PVOV	Over voltage in PV(DC) side	
7	GNDOC	Ground over current	
8	F101	Surge voltage in PV(DC) side	

Table 5.6 H/W Fault 1 Screen Item Description

5.5.9. H/W Fault Screen 2

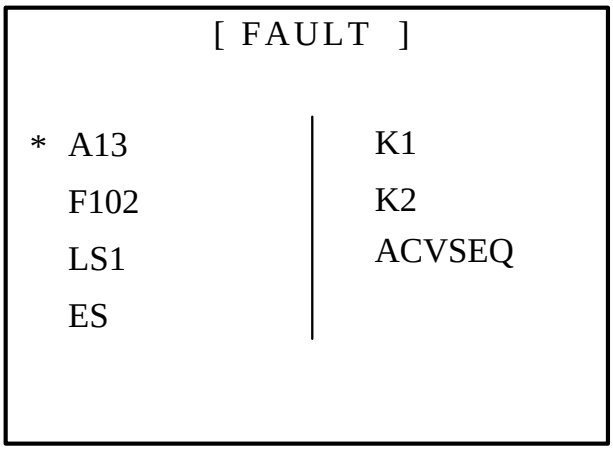


Figure 5.14 H/W Fault 2 Screen

H/W fault information 2 is shown in [FAULT] screen as shown in figure 5.14. Descriptions of the items are as follows :

No.	Item	Description	Remarks
1	A13	Ground fault	
2	F102	Surge voltage in grid(AC) side	
3	LS1	Front door is opened	
4	ES	Emergency stop activation	
5	K1	Grid MCB fault while running	
6	K2	Grid pre-charging MCB fault	
7	ACVSEQ	Phase mismatch in line connections	

Table 5.7 H/W Fault 2 Screen Item Description

5.5.10. Menu Screen

Menu screen comes out when 'Menu' button in SI-DCP is pushed. User can select a menu item by using '↑' and '↓' buttons. '←' is pointing out a currently selected menu item. Corresponding sub screen will come out when the 'ENTER' button is pushed.

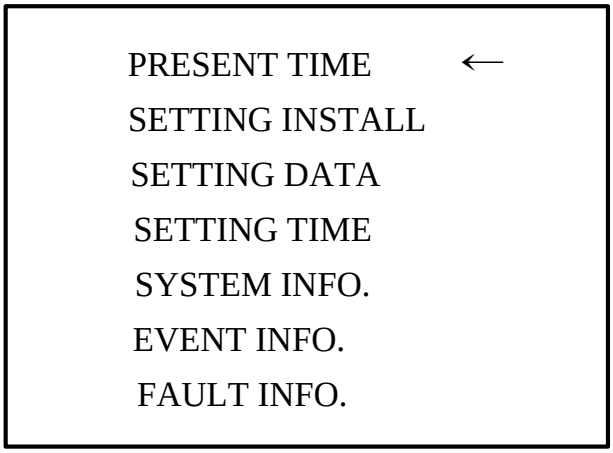


Figure 5.15 Menu Screen

Descriptions of the items are as follows:

No.	Item	Description	Remarks
1	PRESENT TIME	Present time	
2	SETTING INSTALL	Date of PCS installation	
3	SETTING DATA	Parameter setup	
4	SETTING TIME	Time setup	
5	SYSTEM INFO.	System information	
6	EVENT INFO.	Event information	
7	FAULT INFO.	Fault information	

Table 5.8 Menu Screen Item Description

5.5.10.1. Present Time Screen (PRESENT TIME)

When 'Present Time' menu in menu screen (Figure 5.15) is selected, present time screen will come out as shown in figure 5.16. Current year, month, date, hour, minute, and second are shown in this screen.

Year	2008
Month	9
Date	30
Day	Tuesday
Hour	17
Min.	48
Sec.	5

Figure 5.16 Present Time Screen

5.5.10.2. Installation Date Setup Screen (SETTING INSTALL)

When 'SETTING INSTALL' menu in menu screen (Figure 5.15) is selected, [Install Day] screen will come out as shown in figure 5.17. '→' points out currently selected item and it moves among items by pushing 'SET' button in SI-DCP.

Value of the selected item can be changed by pushing '↑' and '↓' buttons. Set values are stored and reflected in the system by pushing '**ENTER**' button in SI-DCP. And then the previous screen, menu screen, will come out. If '**ESC**' button is pushed, set values will not be stored and reflected in the system. And the previous screen, menu screen, will come out.

[Install Day]		
Year	→	2008
Month		9
Date		1
PCS No.		1

Figure 5.17 Installation Date Setup Screen

5.5.10.3. System Parameters Setup (SETTING DATA)

System parameters are set through 'SETTING DATA' menu in figure 5.15. While PCS is running, parameter values cannot be modified. System parameters can be modified through 'SETTING DATA' menu in figure 5.15 only after the system has stopped and unlocked.

A. PCS Running Screen

When the 'SETTING DATA' menu in figure 5.15 is selected while the system is running, pcs running screen will come out as shown in figure 5.18. System parameters cannot be modified in this case. The system should be stopped for the parameter modification.

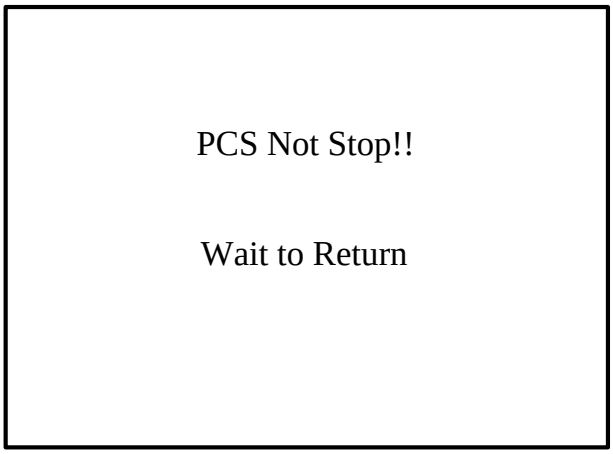


Figure 5.18 PCS Running Screen

B. Password Input Screen

Password input screen comes out when 'SETTING DATA' menu is chosen for modifying parameter values while the system is stopped as shown in figure 5.19. Initial password is '5141'.

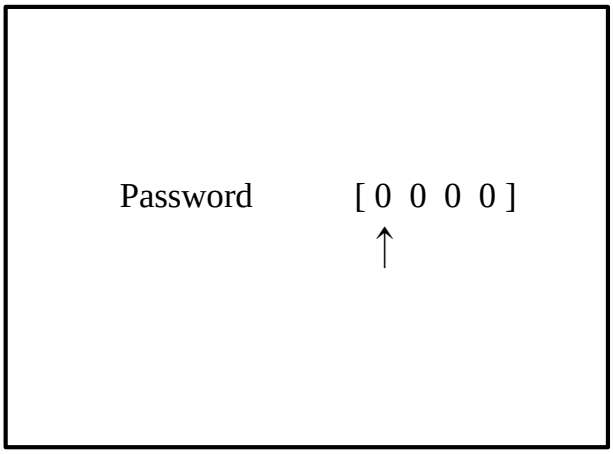


Figure 5.19 Password Input Screen

C. Parameter Screen (Refer '5.6. Parameter Setup')

When the correct password is entered in password input screen, parameter screen will come out as shown in figure 5.20. '←' points out currently selected item and it moves among items by pushing '↑' and '↓' buttons. When 'ENTER' button is pushed, the corresponding sub screen will come out.

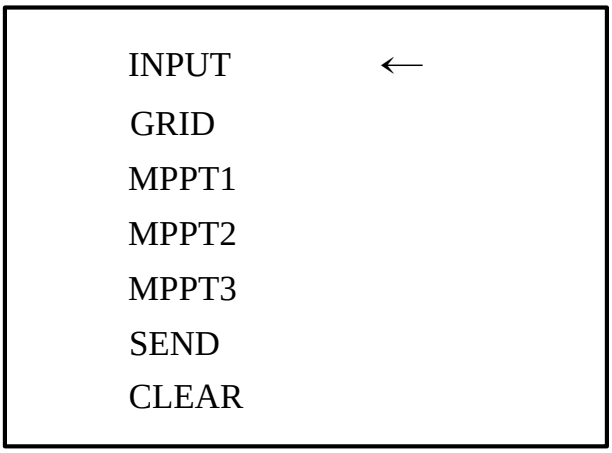


Figure 5.20 Parameter Screen

Descriptions for the items are as follows:

No.	Item	Description	Remarks
1	INPUT	Set the reference input voltage and current value for fault detection	
2	GRID	Set the reference grid voltage, grid current, and grid frequency for fault detection	
3	MPPT1	MPPT related voltage setup	
4	MPPT2	MPPT related time setup	
5	MPPT3	MPPT related power setup	
6	SEND	Sending set data	
7	CLEAR	Clear the data stored in SI-DCP memory	

Table 5.9 Parameter Screen Item Description

NOTICE) For further information about the corresponding sub screens, refer '**5.6. Parameter Setup**'.

5.5.10.4. Present Time Setup Screen (SETTING TIME)

When 'SETTING TIME' menu in menu screen (Figure 5.15) is selected, [Time Set] screen will come out as shown in figure 5.21. '→' points out currently selected item and it moves among items by pushing 'SET' button in SI-DCP. Value of the selected item can be changed by pushing '↑' and '↓' buttons. Set values are stored and reflected in the system by pushing '**ENTER**' button in SI-DCP. And then the previous screen, menu screen, will come out. If '**ESC**' button is pushed, set values will not be stored and reflected in the system. And the previous screen, menu screen, will come out.

[Time Set]		
Year	→	2008
Month		9
Date		30
Day		Tuesday
Hour		18
Min.		45
Sec.		5

Figure 5.21 Present Time Setup Screen

5.5.10.5. System Information Screen (SYSTEM INFO.)

When 'SYSTEM INFO' menu in menu screen(Figure 5.15) is selected, [System Info.] screen will come out as shown in figure 5.22. Date of the installation(Install), Capacity of the PCS(Capacity), MPPT range(Vmppt), Grid voltage(Vgrid), PCS number(PCS No.), MCU S/W version(MCU) and DCP S/W version(DCP) are displayed in this screen.

[System Info.]	
Install	2008-09-01
Capacity	100kW
Vmppt	300 ~ 600
Vgrid	380
PCS No.	1
MCU	2.0
DCP	2.0

Figure 5.22 System Information Screen

5.5.10.6. Event List Screen (EVENT INFO.)

When 'EVENT INFO.' menu in menu screen (Figure 5.15) is selected, [Event List] screen, which shows the fault event history, will come out as shown in figure 5.23. Total 40 fault events can be stored. Screen move is possible with the '↑' and '↓' buttons.

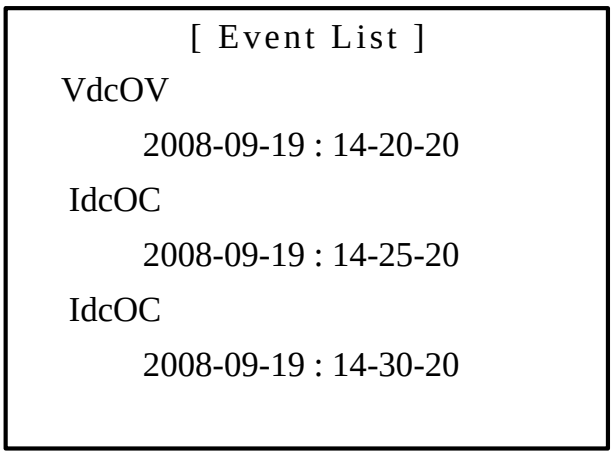


Figure 5.23 Event List Screen

5.5.10.7. Fault List Screen (FAULT INFO.)

When 'FAULT INFO.' menu in menu screen (Figure 5.15) is selected, [FAULT LIST] screen, which shows the fault history, will come out as shown in figure 5.24. Total 30 faults history can be stored. Screen move is possible with the '↑' and '↓' buttons.

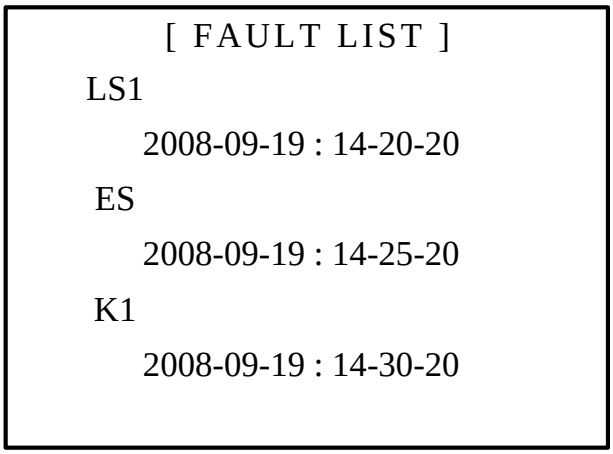


Figure 5.24 Fault List Screen

5.6. Parameter Setup

Parameters can be grouped as following 6 items.

- INPUT: Set the input voltage and current fault detection level
- GRID: Set the grid voltage, output current, and output frequency fault detection level
- MPPT1: Set the MPPT-related voltage values
- MPPT2: Set the MPPT-related time values
- MPPT3: Set the MPPT-related power values
- SEND: Sending Set data related setup

5.6.1. Parameter Functions and Initial Values

Parameter values can be set through the parameter menu screen which is shown in figure 5.20. (Refer '5.5.10.3 System Parameters Setup') The descriptions and initial values of the items in Sub menus of each parameter menu are as follows:

Item	Description	Range		Unit	Initial Value	
		HPC-050HT	HPC-100HT		HPC-050HT	HPC-100HT
VdcOvL	Reference voltage level to detect over voltage of the input PV array	600 ~ 800	600 ~ 800	V	650	650
VdcLvL	Reference voltage level to detect low voltage of the input PV array	250 ~ 310	250 ~ 310	V	280	280
IdcOcL	Reference current level to detect over current of the input PV array	150~350	350~550	A	210	421
IsOcL	Reference current level to detect over current of the grid	100 ~ 400	100 ~800	A	253	507
VsOvL	Reference voltage level to detect overvoltage of the grid	408 ~ 428	408 ~ 428	V_{RMS}	418	418
VsLvL	Reference voltage level to detect low voltage of the grid	324 ~ 354	324 ~ 354	V_{RMS}	334	334
FreqHL	Reference frequency level to detect over-frequency of the grid voltage	60.0 ~ 61.0	60.0 ~ 61.0	Hz	60.5	60.5
FreqLL	Reference frequency level to detect low-frequency of the grid voltage	58.8 ~ 59.8	58.8 ~ 59.8	Hz	59.3	59.3
UL_Set	Upper voltage limit for the MPP Scan note1)	300 ~ 600	300 ~ 600	V	550	550
LL_Set	Lower voltage limit for the MPP Scan note2)	300 ~ 600	300 ~ 600	V	300	300
VD_Set	MPP Rescan voltage error limit note3)	10 ~ 100	10 ~ 100	V	10	10
PD_Set	MPP Rescan power error note 4)	1 ~ 30000	1 ~ 30000	W	1000	1000
SV_Set	Minimum starting voltage of MPP Scan note5)	300 ~ 600	300 ~ 600	V	375	375
VP_Set	MPPT Perturbation value	1 ~ 30000	1 ~ 30000	mV	1500	1500
TL_Set	Time duration of MPP Scan note2)	1 ~ 100	1 ~ 100	sec	10	10
MTL_Set	MPPT Period	1 ~ 30000	1 ~ 30000	msec	500	500

Items of **note** are described in detail next page

Table 5.10 Parameter Functions and Initial Values

note 1) Upper voltage limit of the MPP Scan is only available when the open circuit voltage of the PV array is greater than the set upper voltage limit.

note 2)

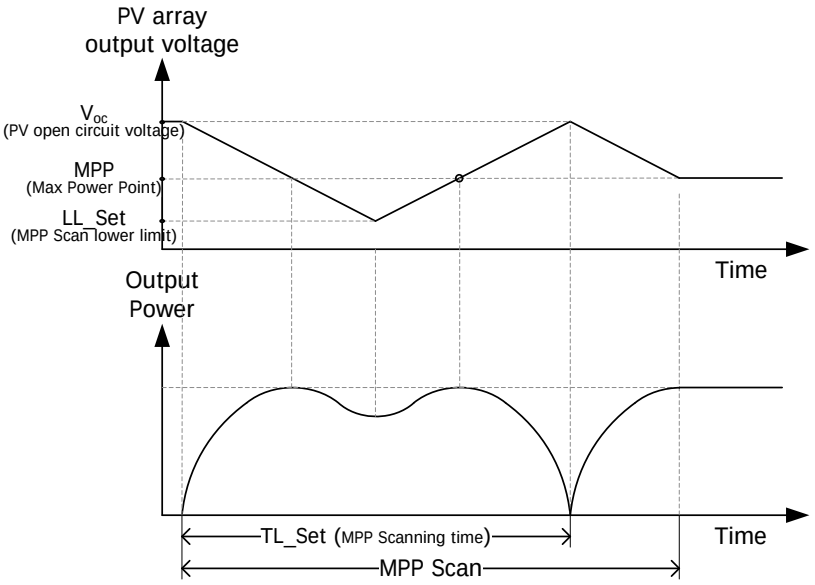


Figure 5.25 LL_Set and TL_Set

note 3) VD_Set: When the difference between the present output voltage value of the PV array and the commanding voltage is over VD_Set for over 10 seconds while MPP tracking process, the system will decide that the MPP tracking process is not correctly proceeding and will restart MPP scanning process.

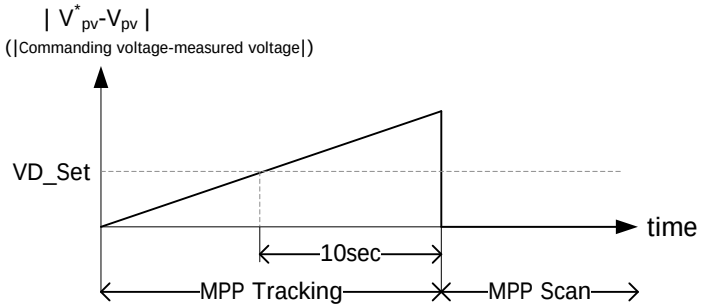


Figure 5.26 VD_Set

note 4) PD_Set: When the generating power of PV array is less than the specified value (PD_set) for over 600 seconds, the system restarts MPP scanning process.

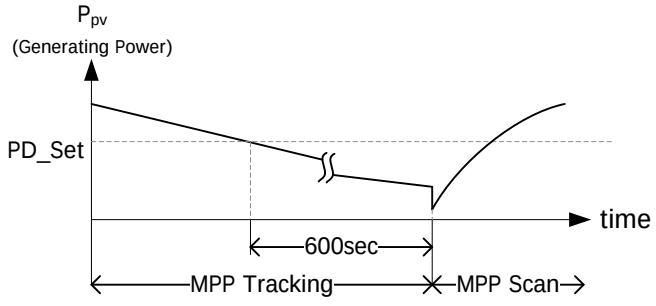


Figure 5.27 PD_Set

note 5) SV_Set: SV_Set is the minimum open circuit voltage of PV array to start MPP scan. While the open circuit voltage of PV array is below this value, the system does not start MPP scan but waits.

5.6.2. INPUT (DC Input Parameters Setup)

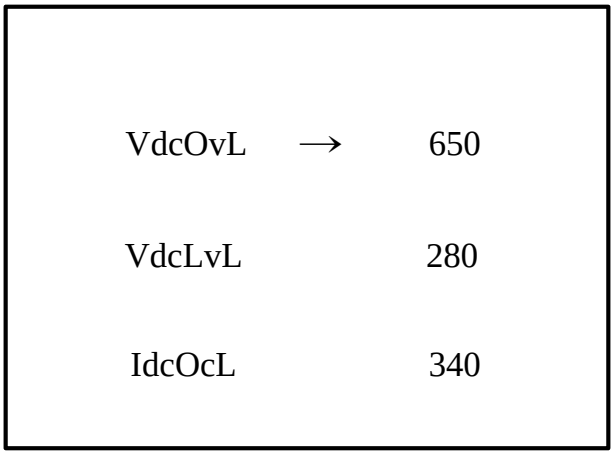


Figure 5.28 Input Screen

When 'INPUT' menu in parameter screen (Figure 5.20) is selected, input screen will come out as shown in figure 5.28. '→' points out currently selected item and it moves among items by pushing 'SET' button in SI-DCP. (refer [**5.6.1. Parameter Functions and Initial Values**] for details of items) Value of the selected item can be changed by pushing '↑' and '↓' buttons. Set values are stored and reflected in the system by pushing '**ENTER**' button in SI-DCP. And then the previous screen, parameter screen, will come out. If '**ESC**' button is pushed, set values will not be stored and reflected in the system. And the previous screen, parameter screen, will come out.

5.6.3. GRID (Grid Parameters Setup)

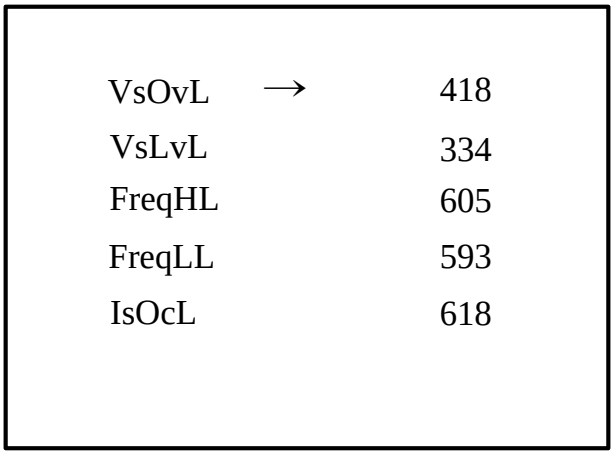


Figure 5.29 Grid Screen

When 'GRID' menu in parameter screen (Figure 5.20) is selected, grid screen will come out as shown in figure 5.29. '→' points out a currently selected item and it moves among items by pushing 'SET' button in SI-DCP. (refer [**5.6.1. Parameter Functions and Initial Values**] for details of items) Value of the selected item can be changed by pushing '↑' and '↓' buttons. Set values are stored and reflected in the system by pushing '**ENTER**' button in SI-DCP. And then the previous screen, parameter screen, will come out. If '**ESC**' button is pushed, set values will not be stored and reflected in the system. And the previous screen, parameter screen, will come out.

5.6.4. MPPT1 (MPPT-Related Voltage Parameters Setup)

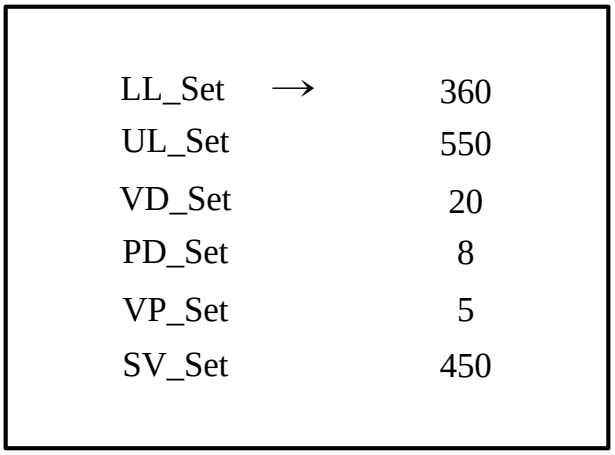


Figure 5.30 MPPT1 Screen

When 'MPPT1' menu in parameter screen (Figure 5.20) is selected, MPPT1 screen will come out as shown in figure 5.30. '→' points out currently selected item and it moves among items by pushing 'SET' button in SI-DCP. (refer [**5.6.1. Parameter Functions and Initial Values**] for details of items) Value of the selected item can be changed by pushing '↑' and '↓' buttons. Set values are stored and reflected in the system by pushing '**ENTER**' button in SI-DCP. And then the previous screen, parameter screen, will come out. If '**ESC**' button is pushed, set values will not be stored and reflected in the system. And the previous screen, parameter screen, will come out.

5.6.5. MPPT2 (MPPT-Related Time Parameters Setup)

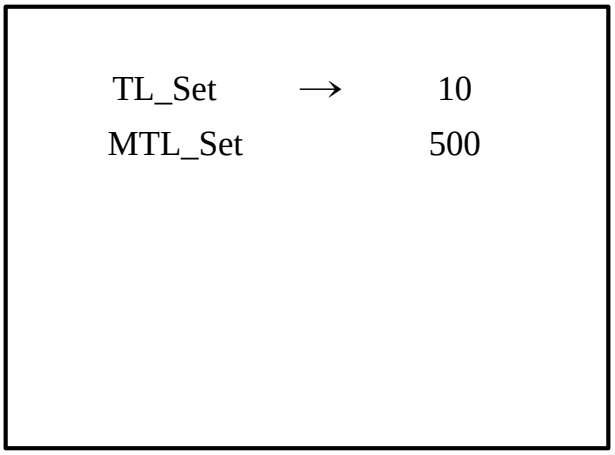


Figure 5.31 MPPT2 Screen

When 'MPPT2' menu in parameter screen (Figure 5.20) is selected, MPPT2 screen will come out as shown in figure 5.31. '→' points out a currently selected item and it moves among items by pushing 'SET' button in SI-DCP. (refer [**5.6.1. Parameter Functions and Initial Values**] for details of items) Value of the selected item can be changed by pushing '↑' and '↓' buttons. Set values are stored and reflected in the system by pushing '**ENTER**' button in SI-DCP. And then the previous screen, parameter screen, will come out. If '**ESC**' button is pushed, set values will not be stored and reflected in the system. And the previous screen, parameter screen, will come out.

5.6.6. SEND (Send Set Parameter Data)

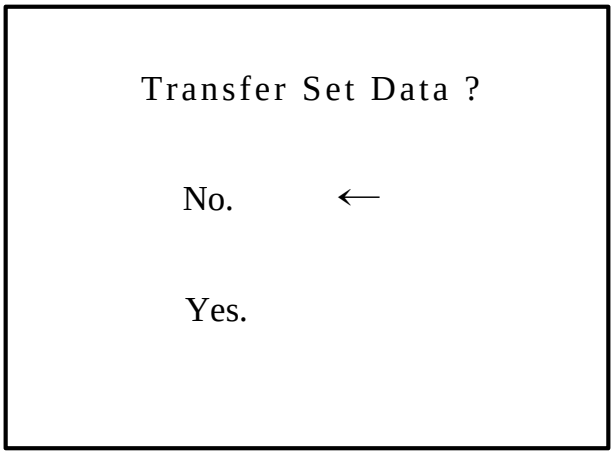


Figure 5.32 SEND Screen

When 'SEND' menu in parameter screen (Figure 5.20) is selected, SEND screen will come out as shown in figure 5.32. '→' points out currently selected item and it moves among items by pushing '↑' and '↓' buttons. Set values are stored and reflected in the system by pushing '**ENTER**' button in SI-DCP. And then the previous screen, parameter screen, will come out. If '**ESC**' button is pushed, set values will not be stored and reflected in the system. And the previous screen, parameter screen, will come out.

5.6.7. CLEAR (Clear the data in SI-DCP memory)

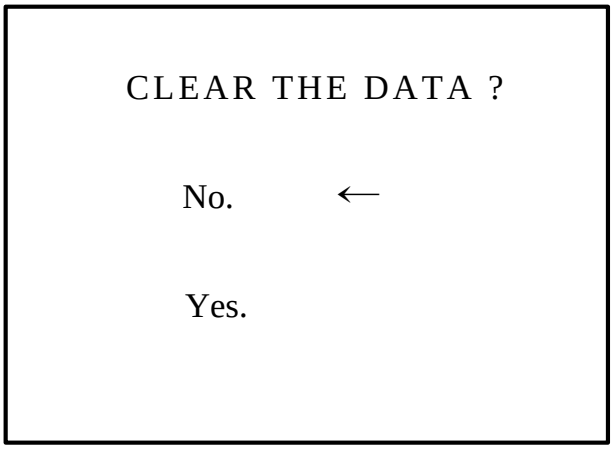


Figure 5.33 CLEAR Screen

When 'CLEAR' menu in parameter screen (Figure 5.20) is selected, CLEAR screen will come out as shown in figure 5.33. '←' points out currently selected item and it moves among items by pushing '↑' and '↓' buttons. Set values are stored and reflected in the system by pushing '**ENTER**' button in SI-DCP. And then the previous screen, parameter screen, will come out. If '**ESC**' button is pushed, set values will not be stored and reflected in the system. And the previous screen, parameter screen, will come out.

6. Faults and Solutions

System faults and their solutions are described in this chapter. When a fault is occurred, the system will immediately stop its operation and then restart after 20 seconds. Description of the fault is displayed on the LCD before it restarts. User can see that the faults were occurred or not by seeing fault event history. (Refer **5.5.10.6. Event List Screen**, **5.5.10.7. Fault List Screen**)

6.1. Fault list

PCS detects the faults that are shown in below table. The faults can be grouped to Alarm-group and Trip-group. The system will immediately stops its operation and then restarts after 20 seconds when any fault is detected.

Group	Fault	Description	Remarks
Alarm	Synch Warning	Fails to synchronize the phases of the system with the grid's	
	ACOV Warning	Grid over-voltage	
	ACLV Warning	Grid low-voltage	
	ACOF Warning	Grid over-frequency	
	ACLF Warning	Grid low-frequency	
	PVOV Warning	Input over-voltage	
	PVLV Warning	Input low-voltage	
	ACOC Warning	Grid over-current	
	PVOC Warning	Input over-current	
	TS4_OT Warning	Stack over-temperature	
	TS2_OT Warning	Filtering reactor over-temperature	
	TS3_OT Warning	Transformer over-temperature	
Trip	ODU Fault	Power element short circuit in U-phase	
	ODV Fault	Power element short circuit in V-phase	
	ODW Fault	Power element short circuit in W-phase	
	PVOC Fault	Input over-current detection by H/W	
	ACOC Fault	Grid over-current detection by H/W	
	PVOV Fault	Input over-voltage detection by H/W	
	GNDOC Fault	Unbalanced grid current detection by H/W	
	F101 Fault	Input surge voltage	
	A13 Fault	Ground fault	
	F102 Fault	Grid surge voltage	
	LS1 Fault	Front door open	
	ES Fault	Emergency stop button is pushed	
	K1 Fault	Grid MCB fault while running	
	K2 Fault	Fault of the initial charging grid MCB	
	ACVSEQ Fault	Grid voltage phase sequence fault	

Table 6.1 Alarm and Trip List

6.2. Solultions for Faults

The system automatically restarts when the reasons of the fault, which is on the list table in 6.1, is resolved. If the system does not restart with displaying the fault description on the LCD or the same fault is occurred frequently, solve the reasons of the fault as described below. (PV array low voltage is not considered as a fault that should be treated.)

Fault	Fault description	Solution	Remarks
ACLV Warning	Grid under-voltage	Check the grid power. When the grid voltage is in the normal range, the system restarts after 5 minutes wait.	
ACOV Warning	Grid over-voltage	Check the grid power. When the grid voltage is in the normal range, the system restarts after 5 minutes wait.	
Synch Warning	Fails to synchronize the phases of the system with the grid's	Check the grid power. When the phase synchronization succeeds, the system restart.	
ACLF Warning	Grid under-frequency	Check the grid power. When the grid frequency is in the normal range, the system restarts after waiting 5 minutes.	
ACOF Warning	Grid over-frequency	Check the grid power. When the grid frequency is in the normal range, the system restarts after waiting 5 minutes.	
PVLV Warning	Input under-voltage	When input voltage is in the normal range, the system automatically restarts.	
PVOV Warning, PVOV Fault	Input over-voltage	When input voltage is in the normal range, the system automatically restarts.	
PVOC Warning, PVOC Fault	Input over-current	When the fault is frequently occurs, turn the DC and AC circuit breakers off and call A/S.	Contact A/S
ACOC Warning, ACOC Fault	Grid over-current	When the fault is frequently occurs, turn the DC and AC circuit breakers off and call A/S.	Contact A/S
TS4_OT Warning	Power part over-temperature	When the fault is frequently occurs, turn the DC and AC circuit breakers off and call A/S.	Contact A/S
TS2_OT Warning	Filter reactor over-temperature	When the fault is frequently occurs, turn the DC and AC circuit breakers off and call A/S.	Contact A/S

TS3_OT Warning	Grid transformer over-temperature	When the fault is frequently occurs, turn the DC and AC circuit breakers off and call A/S.	Contact A/S
ODU Fault ODV Fault ODW Fault	Power element's gate fault	When the fault is frequently occurs, turn the DC and AC circuit breakers off and call A/S.	Contact A/S
A13 Fault	DC ground fault	Turn the DC and AC circuit breakers off and call A/S.	Contact A/S
K1 Fault	Grid MCB fault while running	Turn the DC and AC circuit breakers off and call A/S.	Contact A/S
K2 Fault	Grid start charging MCB fault	Turn the DC and AC circuit breakers off and call A/S.	Contact A/S
GNDOC Fault	Unbalanced grid current detection by H/W	When the fault is frequently occurs, turn the DC and AC circuit breakers off and call A/S.	Contact A/S
ACVSEQ Fault	Grid voltage phase sequence fault	Exchange 2 phases with each other and connect them to the system.	
LS1 Fault	Front door open	Check the door open switch of upper part of the front door.	
ES Fault	Emergency stop button is pushed.	Release the emergency stop button by turning it to the right.	
F101 Fault	Input surge voltage	Turn the DC and AC circuit breakers off and call A/S.	Contact A/S
F102 Fault	Grid surge voltage	Turn the DC and AC circuit breakers off and call A/S.	Contact A/S

Table 6.2 Solutions for Faults

7. Maintenance

⚠ DANGER

- Turn the supply circuit breaker off and wait for 1 hour for checking the system. It may cause electric shock.
- Check that the voltage difference between Vdc (+) and Vdc (-) terminals is below 5V.
- Maintenance should be done by authorized personnel.
- Detach the metallic substances, such as watch and ring, from the inspecting personnel. And use insulated tools for maintenance to prevent electric shock or accidents.

7.1. Maintenance

7.1.1. Daily Check

Check the followings:
① Abnormality of the installed location and environment
② Abnormality of the cooling fan
③ Abnormal vibration and sound
④ High-temperature and discoloration
⑤ Abnormal smell

7.1.2. Cleanning

The system should always be operated in clean environment.
When the dusts are filed on the cooling fan or external case, turn the system and AC/DC circuit breakers off and clean the system using vacuum cleaner. If possible, ask manufacturer to clean the system regularly.

NOTE 1) Do not use acetone, benzene, toluene, and alcohol for cleaning. They may melt the paint of the case.
NOTE 2) Do not use detergent or alcohol to clean the screen of the digital operator.

7.1.3. Regular Check

Consult manufacturer for regular check:
① Abnormality of the cooling fan ☞ Cleaning or exchanging part
② Loose bolt ☞ Vibration and temperature of the site may cause a loose bolt. Fasten the bolts tightly.
③ Corrosion and damage of conductors and insulators
④ Measure the insulation resistance
⑤ Checking and exchanging of smoothing capacitors and relays

7.2. Check List

	Check item	Check list	Period			Checking method	Judgment	Tool
			daily	Regular				
				1-year	2-year			
Front Side	Overall	Ambient temperature, humidity, dust	○			Visual	Normal in -10℃～40℃. (No freezing). No condensation in 90% humidity	Thermometer, Hygrometer, Recorder
	Exterior	Vibration, sound	○			Visual, sound	Normal	
	Supply voltage	(1)Main circuit (2)Control power voltage	 ○			(1)Measure output U.V voltage of AC circuit breaker and PCS output current. (2)Measure control voltage	AC voltage and current is in the allowed range	Tester, Digital multimeter
Main Circuit	Overall	(1)Panel inner filter:dust, clean (2)Loose bolt (3)Parts over-heat (4)Inside of panel	○ ○	○ ○		(1)Visual (2)Fasten bolts (3)Visual	(1)No dust file (2)Normal (3)Normal	
	Power stack	(1)Sound while running (2)Cleanness		○ ○		(1) Sound (2) Visual		
	Connecting line	(1)Twist (2)Wire damage		○ ○		(1) Visual (2) Sound	(1) No twist (2) No damage	
	Terminal block	Overall		○		Visual	No damage	
	Smoothing capacitor	(1)Leakage (2)Lifetime. Deformation (3)Electric capacity	○ ○		 ○	(1) Visual (2) Visual (3)measure using capacity meter	 (3)≥80% of rated capacity. Change : 5 years	Capacity meter
	Relay	(1)Sound (2)Contact point		○ ○		(1)Sound (2)Visual	(1) Normal (2) No damage	
	Circuit Breaker	(1)Overall		○		(1)Performance check	(1) No breakdown	
	Fuse	(1)Overall		○		(1)Visual	(1) No damage	
	Surge Arrester	(1)Overall		○		(1)Visual	(1) No damage	
	Insulation resistor	(1)Ground/insulation fault detector		○		(1)Visual	(1) Normal insulation resistor	Option
	Limit switch	(1) Overall		○		(1)Visual	(1) No damage	
	Temperature detector	(1) Overall		○		(1)Visual	(1) No damage	
	Emergency stop button	(1) Overall		○		(1)Visual	(1) No damage	
	Resistor	(1)Discoloration (2)Disconnection		○ ○		(1)Visual (2)Check with tester	(1) Normal color (2) Measured error : ≤±10%	Tester, Digital multimeter
Control Power	Control power	(1)Aux. power (A15) (1)Aux. power (A16)		○		(1) Check SMPS output voltage. (2) Check SMPS output voltage.	(1)Output voltage: 15,5V,-15V (1)output voltage : 24V	Digital multimeter
Cooling Part	Cooling fan	(1)Vibration (2)contact point	○	○		(1) Rotate without power (2) Start	(1)Smooth rotation (2)No looseness Change: 2～3 years	
Display	Display	(1)LED disconnection (2)Cleanness	○ ○			(1)Visual	(1)Lights on	

Table 7.1 Check List