

REV	Revision	Compiled	Date
0	1 st Edition	S.Y. Shin	24/04/06
1	Page.7 Table, Page.10 Diagram Revision	J.H. Ahn	26/10/07
2	Overall Context	S.Y. Shin	31/10/07
3	Cable Spec. / Elec. & Mech. Spec. Revision	S.Y. Shin	22/04/08
4	Product Type Change (HiS-M184SF→HiS-M185SF)	S.Y. Shin J.H. Ahn	13/11/08
5	Advanced Mechanical Test (5,400 Pa)	S.Y. Shin	17/03/09
6	Earth Method, Clamping Position	J.H. Ahn	18/12/09
7	SG-Series Included / Clamp Position Modification	S.H. Woo	27/01/10
8	Specification Modification	S.H. Woo	28/06/10
9	Attachment 1 Included	J.H. Ahn	29/06/10

Installation Manual

Subject	PV Module Installation Manual
Applicable Process	PV System Installation
Applicable Products	All PV Module Products



Solar Energy Dept.

Approved	S.H. Song	File No.	Installation Manual (Rev.9).doc
Checked	S.Y. Shin	Doc. No.	`DMP-C60A-001
Compiled	J.H. Ahn	Pages	18 Inc. Cover

1. General Information

This installation manual provides information for Hyundai Crystalline-Silicon Photovoltaic Modules.

Serial Number Structure: YYMMDD-XX-MXXSF(SG)-0001(~9999)

(Ex. 090819-11-M221SG-0005)

- ◆ YYMMDD: Production Date
- ◆ XX: Production Line
- ◆ MXXSF: Type of Module
- ◆ 0001~9999: Production Number

1.1 Disclaimer of Liability

Hyundai Heavy Industries (HHI) shall be indemnified for loss, damage and cost increase related to the use of this manual.

The information included in this manual is considered to be reliable, but is not considered as lawful of direct/indirect express or guarantee.

Without prior notice, HHI holds rights to change the products, the specification and the manual.

1.2 NOTICE

Installation of a PV module requires a high level of installation expertise. Therefore an installation engineer must fully understand this manual before installation, wiring, operation and handling. Installation and wiring must be executed by an authorized electrical engineer or by someone under supervision of such an engineer.

1.3 DANGER

- ◆ Electric parts such as connectors may cause burns, discharge or shock regardless of whether or not they are connected.
- ◆ The back sheet of the PV module must be kept from any damage or scratching to prevent electric shock and fire.
- ◆ Unauthorized personnel are not permitted to open the cover of a junction box to prevent electric shock.
- ◆ Do not stand or walk on a PV module.
- ◆ Do not disassemble or remove any part of a PV module to prevent electric shock, fire or damage.

- ◆ For other parts of a PV system such as inverters, batteries and charge controllers, please follow the safety instruction of the manufacturers.

1.4

WARNING

- ◆ An installation engineer must be careful of any risk of electric shock or injury during installation.
- ◆ Under sunlight or any other light source, a PV module generates DC electricity. Even though the voltage and the current of the PV module is low, the risk of electric shock and burn still exists.
- ◆ During installation, the front side of PV modules must be covered to avoid electricity generation.
- ◆ The risk of electric shock increases with higher voltage in series connection and with higher current in parallel connection.
- ◆ All PV modules and installation instruments must be dry when being installed.
- ◆ Children and unauthorized persons must keep distance from PV modules.
- ◆ All PV modules must be earthed.
- ◆ Safety equipment is necessary to protect any contact to 30 Vdc or above.
- ◆ A PV module should be carried by two persons with slip-proof gloves.
- ◆ Please don't pick up PV modules using cables or the junction box.
- ◆ Please don't drop anything on PV modules.
- ◆ Please check the safety of all other parts of the PV system to prevent any electric shock and fire.
- ◆ Please do not install where inflammable gas or vapor exist because sparks may occur.
- ◆ Please do not leave un-fixed or unsafe PV modules unattended.
- ◆ Please do not drop a PV module.
- ◆ Please do not use any damaged PV module to prevent any fire, electric shock or injury.
- ◆ Please do not focus light on a PV module to prevent any fire and damage.
- ◆ Please do not touch the terminals of a junction box to prevent any electric shock or injury.
- ◆ Please do not re-arrange the bypass diodes to prevent any electric shock or injury.

1.5

CAUTION

- ◆ Only for proper use.
- ◆ Please do not use paint or adhesive to prevent any performance drop, damage, or incapability of back sheet or front glass.

2. General Safety

Please follow all requirements of authorization, installation and inspection.

- ◆ Please contact an authorized person to find out all authorization, installation, and inspection requirements.
- ◆ All PV systems must be earthed. If there is no special regulation, please follow the National Electrical Code (US), the Canadian Electric Code (Canada) or other national codes.
- ◆ Please check the strength of buildings or support structures where PV modules are designed to be installed. Some additional structures may be necessary for safe installation. All installation must conform with all fire safety regulations. Additional parts to check earth failure, fuse and isolation may be necessary.
- ◆ Do not use different PV modules in the same PV system.
- ◆ Please follow all safety regulations of other parts of the PV system.

UL Listing Information

The below must be considered carefully for installation to meet UL requirements.

- 1) Please use single or non-hollowed copper wire. For module connection and ambient use, please use radiation-proof cables.
- 2) Please read carefully all technical requirements about installation and specifications in this paragraph.
- 3) The module frame must be earthed. If an earth wire over 6 mm² (10 AWG) is required, an installer must provide proper terminal connectors.

3. Installation

3.1 General

- ◆ Before installation and operation, this manual must be well understood. This paragraph includes necessary information of electrical and mechanical specifications.
- ◆ During installation, PV modules must be fixed considering any possible wind load and snow load.
- ◆ Do not drill on the module frame for an additional hole. Doing so will render the warranty invalid.
- ◆ Installation materials must be resistant against any corrosion to protect the module frame and installation structures.
- ◆ During installation, please avoid any possible shade by buildings or trees. In particular, please consider any partial shade during daylight hours.
- ◆ For more information about standard installation, please inquire to authorized personnel of HHI.

3.2 Notes on Installation

- ◆ A gap between a PV module frame and an installed object is necessary for cooled air circulation.
Do not seal this gap.
- ◆ The recommended Standoff height is a minimum of 10.16 cm (4 inch) to conform with UL First Class C.

3.3 General Operation Condition

HHI recommends PV modules should be operated under General Operation Conditions (GOC). Do not install at a site without GOC approval or under the special conditions outlined below.

1. General Operation Conditions

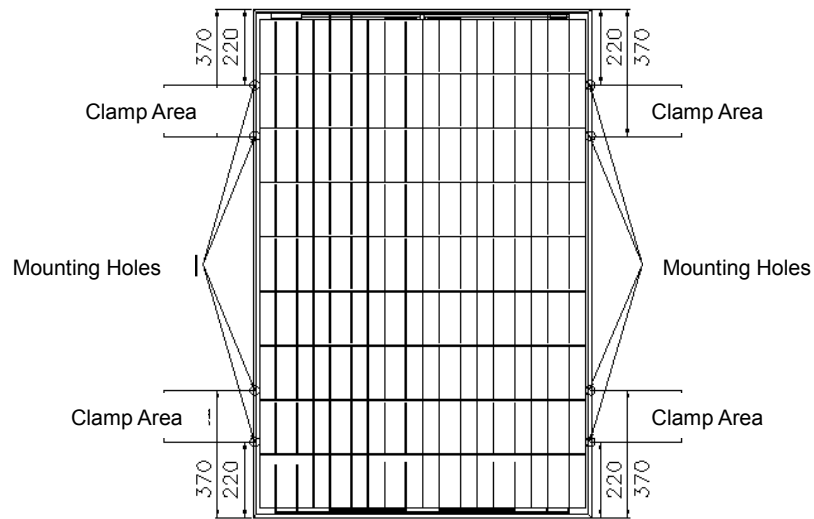
- (1) Ground purpose only.
- (2) Ambient Temperature: -20°C (-4°F) $\sim$ 40°C (104°F)
- (3) Relative Humidity: 45% $\sim$ 95%
- (4) Installation Site: Max. 1,000 m (3,280 ft) above sea level. If wind load is not greater than $5,400 \text{ N/m}^2$, installation over 1,000 m (3,280 ft) above sea level is permitted.

2. Special Conditions

- (1) Please consider that actual operation conditions may differ with the general operation conditions.
- (2) Chloride is an important factor to be considered carefully during installation.
- (3) Hail, snow, sand, and dirt are important factors to be considered carefully during installation.
- (4) Air pollution, chemical gases, acid rain, and smoke are important factors to be considered carefully during installation.
- (5) Modules must not be installed nor operated in areas where salinity damage is above normal or excessive.

3.4 Mounting Instruction

All PV modules must be fixed firmly by at least 4 points on the longer frames or shorter frames. Except for screw mounting method, it is recommended to install additional clamps on the bottom side of the PV modules to prevent frame slip-off due to heavy snow load. (See the Attachment 1).

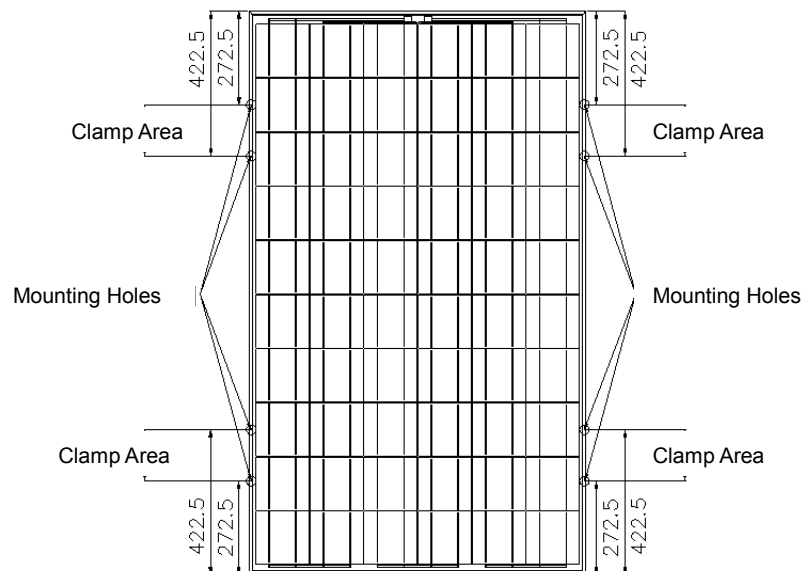


※ Notice

Mounting Holes Locations: 220 mm and 370 mm from the end of longer frames

See the Attachment 1 for more information about mechanical strength

Picture 1. SF-Series Installation Position



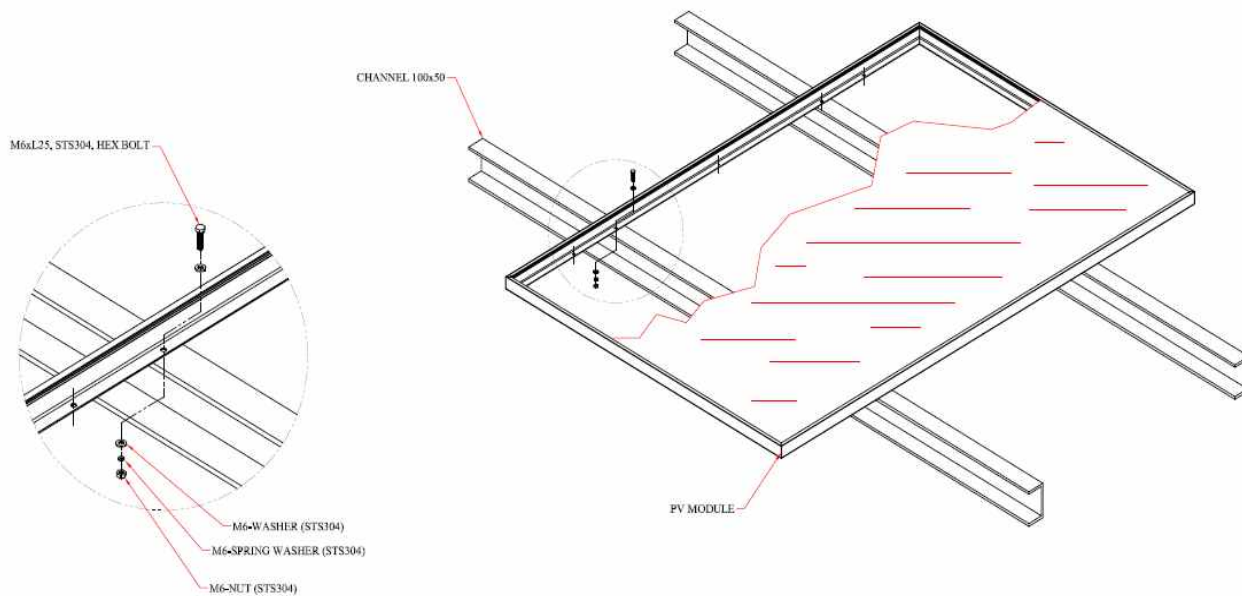
※ Notice

Mounting Holes Locations: 272.5 mm and 422.5 mm from the end of longer frames

See the Attachment 1 for more information about mechanical strength

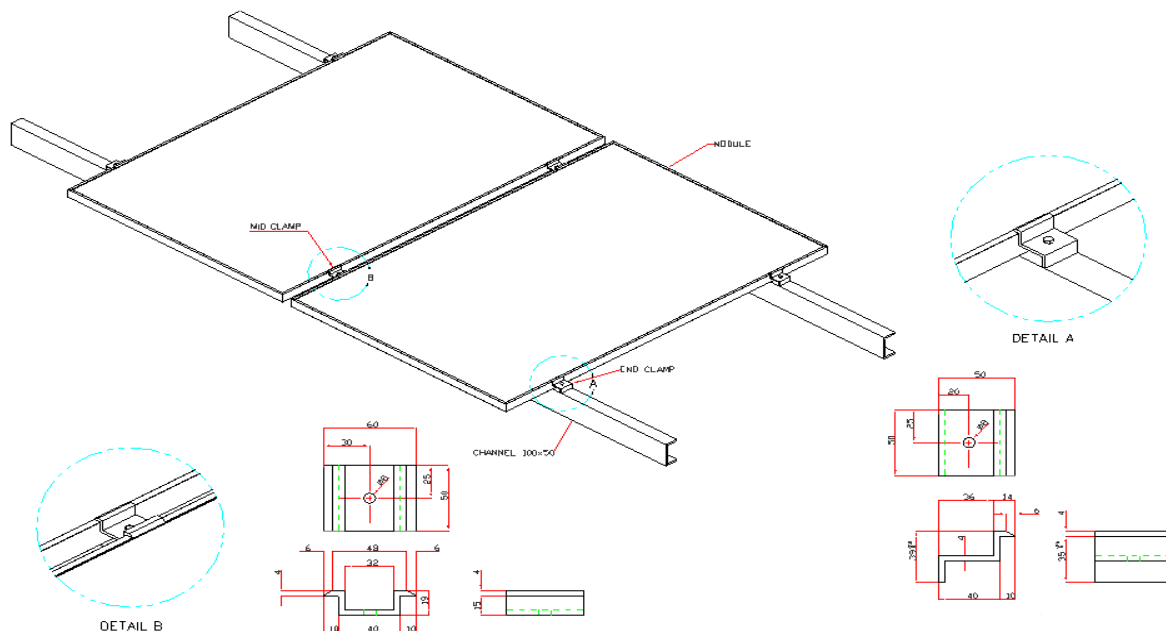
Picture 2. SG-Series Installation Position

(1) Screw Mounting Method



Picture 3. Screw Mounting Method

(2) Clamping Mounting Method



Picture 4. Clamping Mounting Method

4. Specifications

4.1 Notes on Specifications

- ◆ Nominal Electrical Characteristics : Within 3% under Standard Test Conditions (STC),
Standard Test Conditions (STC): Irradiation 1,000 W/m², Cell Temperature 25 °C, 1.5 AM
- ◆ Electrical Characteristics 1 (Multi-Crystalline Type)

	HiS-MxxxSF (xxx; Nominal Power Value)						
Normal Power (Pmax)	194	197	200	203	206	209	212
Voltage at Pmax (Vmpp)	26.2	26.4	26.4	26.6	26.8	26.9	27.0
Current at Pmax (Imp)	7.5	7.5	7.6	7.7	7.7	7.8	7.9
Open circuit voltage (Voc)	32.9	33.0	33.1	33.3	33.4	33.5	33.6
Short circuit current (Isc)	8.1	8.1	8.2	8.2	8.2	8.3	8.3
Module efficiency	13.4	13.6	13.8	14.0	14.2	14.4	14.6
Temp. coefficient of Pmax [%/K]	-0.43						
Temp. coefficient of Voc [%/K]	-0.32						
Temp. coefficient of Isc [%/K]	+ 0.056						
Output tolerance [%]	+3/-0						
Maximum system voltage [Vdc]	1,000						
Cell quantity in series [pcs]	54						
Bypass diodes [pcs]	3						
Cell Type	6 inches, Multi-crystalline Silicon Cell						
Certification	IEC 61215 (Ed.2), IEC 61730 & UL 1703						

	HiS-MxxxSG (xxx; Nominal Power Value)						
Normal Power (Pmax)	215	218	221	224	227	230	233
Voltage at Pmax (Vmpp)	28.7	28.9	29.0	29.2	29.3	29.4	29.6
Current at Pmax (Imp)	7.5	7.6	7.7	7.7	7.8	7.9	7.9
Open circuit voltage (Voc)	36.3	36.4	36.6	36.7	36.8	36.9	37.1
Short circuit current (Isc)	8.2	8.3	8.3	8.3	8.3	8.4	8.4
Module efficiency	13.3	13.5	13.7	13.9	14.0	14.2	14.4
Temp. coefficient of Pmax [%/K]	-0.43						
Temp. coefficient of Voc [%/K]	-0.32						
Temp. coefficient of Isc [%/K]	+ 0.056						
Output tolerance [%]	+3/-0						
Maximum system voltage [Vdc]	1,000						
Cell quantity in series [pcs]	60						
Bypass diodes [pcs]	3						
Cell Type	6 inches, Multi-crystalline Silicon Cell						
Certification	IEC 61215 (Ed.2), IEC 61730 & UL 1703						

◆ Electrical Characteristics 2 (Mono-Crystalline Type)

	HiS-SxxxSF (xxx; Nominal Power Value)						
Normal Power (Pmax)	197	200	203	206	209	212	215
Voltage at Pmax (Vmpp)	26.4	26.5	26.6	26.8	26.9	27.0	27.1
Current at Pmax (Impp)	7.5	7.6	7.7	7.7	7.8	7.9	8.0
Open circuit voltage (Voc)	33.0	33.1	33.2	33.4	33.5	33.6	33.7
Short circuit current (Isc)	8.2	8.2	8.2	8.2	8.2	8.3	8.3
Module efficiency	13.6	13.8	14.0	14.2	14.4	14.6	14.8
Temp. coefficient of Pmax [%/K]	-0.44						
Temp. coefficient of Voc [%/K]	-0.34						
Temp. coefficient of Isc [%/K]	+ 0.052						
Output tolerance [%]	+3/-0						
Maximum system voltage [Vdc]	1,000						
Cell quantity in series [pcs]	54						
Bypass diodes [pcs]	3						
Cell Type	6 inches, Mono-crystalline Silicon Cell						
Certification	IEC 61215 (Ed.2), IEC 61730 & UL 1703						

	HiS-SxxxSG (xxx; Nominal Power Value)						
Normal Power (Pmax)	218	221	224	227	230	233	236
Voltage at Pmax (Vmpp)	28.9	29.1	29.2	29.3	29.4	29.6	29.7
Current at Pmax (Impp)	7.6	7.6	7.7	7.7	7.9	7.9	8.0
Open circuit voltage (Voc)	36.4	36.6	36.7	36.8	37.0	37.1	37.2
Short circuit current (Isc)	8.3	8.3	8.3	8.3	8.4	8.4	8.4
Module efficiency	13.5	13.7	13.9	14.0	14.2	14.4	14.6
Temp. coefficient of Pmax [%/K]	-0.44						
Temp. coefficient of Voc [%/K]	-0.34						
Temp. coefficient of Isc [%/K]	+ 0.052						
Output tolerance [%]	+3/-0						
Maximum system voltage [Vdc]	1,000						
Cell quantity in series [pcs]	60						
Bypass diodes [pcs]	3						
Cell Type	6 inches, Mono-crystalline Silicon Cell						
Certification	IEC 61215 (Ed.2), IEC 61730 & UL 1703						

◆ Mechanical Characteristics (All types)

Description	HiS-MxxxSF & HiS-SxxxSF
Length, mm (inches)	1,476 (58.1)
Width, mm (inches)	983 (38.7)
Depth, mm (inches)	35 (1.38)
Weight, kg (pounds)	17.0 (37.5)

Description	HiS-MxxxSG & HiS-SxxxSG
Length, mm (inches)	1,645 (64.8)
Width, mm (inches)	983 (38.7)
Depth, mm (inches)	35 (1.38)
Weight, kg (pounds)	19.0 (41.9)

- ◆ The specifications in the datasheet are tested under STC conditions. In normal conditions, the data would be different.
- ◆ In normal conditions, PV modules may have higher levels of voltage or current than in STC conditions. Therefore the correction factors must be applied as below.
 - Current Correction Factor: 1.25
 - Voltage Correction Factor

Ambient Temperature		Correction Factor
Celsius (°C)	Fahrenheit (°F)	
10 ~ 25	50 ~ 77	1.06
0 ~ 9	32 ~ 49	1.10
-10 ~ -1	14 ~ 31	1.13
-20 ~ -11	-4 ~ 13	1.17
-40 ~ -21	-40 ~ -5	1.25

(Source: American National Electrical Code)

4.2 Mechanical Loading

As **Attachment 1** shows, a PV module has two installation positions on each of four sides, totaling 8 positions. Please select four installation positions on two opposing sides. The selected positions must have the same distance from the edge of the frame. Otherwise the PV module may not hold the nominal load on the PV module surface of a maximum 5,400 N/m² (112 lb/ft²).

5. Wiring

5.1 General

All wiring must adhere to the proper electrical codes. The wiring must adhere to the NEC (US) or the CEC (Canada).

- ◆ Wiring work must be done by a certified and authorized engineer.
- ◆ Wiring must secure the safety of the human body and prevent self-damage.
- ◆ PV modules for one serial connection must have identical electrical characteristics (V_{mpp} , I_{mpp} , V_{oc} , I_{sc}).
- ◆ Do not connect PV modules directly parallel to one another without the junction box.

5.2 Module Wiring

- ◆ The maximum number of modules in a series connection is 24.
- ◆ The maximum system voltage must not be more than 1,000 V.
- ◆ PV modules are not designed to be connected to loads directly. Therefore, a proper inverter must be connected.
- ◆ Bypass diodes are equipped on the modules from the factory. Incorrect connection may cause damage to the bypass diodes, cable and junction box.

5.3 Array Wiring

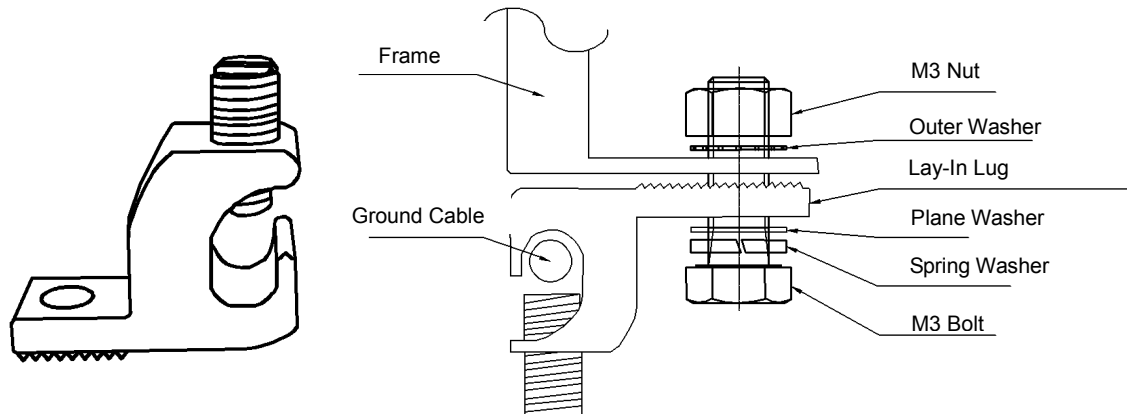
'Array' is defined as a module arrangement with combined electrical connection. The array must be insulated to resist against the possible maximum open-circuit voltage. Also, solar radiation-proof copper wires must be used for array wiring. Installation must be considered in connection with local electrical specifications.

5.4 Earth Ground Wiring

To prevent electric shock and fire, an earth must be done on the frames of PV modules and array. The array frame must be earthed according to NEC Article 250 (US) or CEC (Canada). There is an earth hole in the center of the module frame. Using this hole, an earth conductor and the module frame must be connected and earthed. (See the Picture 7.)

(1) Lay-In Lug

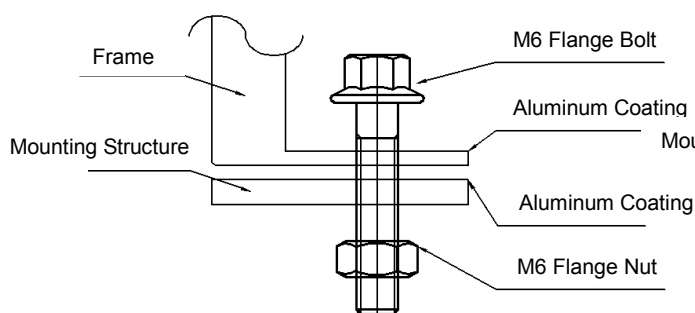
The lay-in lug from ILSCO (Part No. GBL-4DBT) or other certified products which are equivalent or better in quality can be used, and must be connected to the ground hole (4 mm) on the module frame. Because the module frame is anodizing-coated to prevent corrosion, the lay-in lug and outer washer must be sawtooth and must be tightened up to a proper torque level using a torque wrench. Bolts, nuts, washers and lay-in lugs must be stainless.



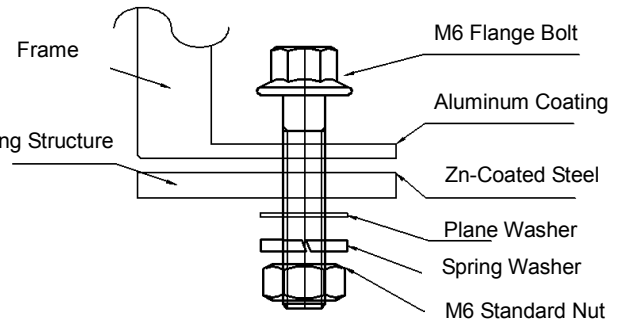
Picture 5. Lay-In Ground Lug

(2) Lay-In Lug Using Mounting Structure

When a mounting hole (7 mm) on the module frame and grounded mounting structure are connected by 6 mm flange bolts and nuts, the module can be installed and grounded at the same time. Detailed installation standard must be complied with each country's electrical regulations. If the mounting structures are coated, connection must be tightened up to a proper torque level using a torque wrench. Bolts and nuts must be stainless.



Picture 6. Al-Coated Mounting Structure



Picture 7. Zn-Coated Steel Mounting Structure

5.5 Module Terminations

A junction box is equipped on each PV module for system array. Also, quick connectors are equipped for module connection. For more information about electrical connection, please inquire to an authorized engineer of HHI.

5.6 Junction Box & Terminals

A PV module is equipped with plus and minus connectors and a junction box with bypass diodes. Each connector is designed for one polarity, respectively. (On the junction box, the polarity is clearly marked.) (See the Picture 8, 9.)

* Applied Cable

- | | | |
|--------------------------------|---|---------|
| 1) Type; | Conductor-Stranded tin Plated Copper | |
| | Insulation-Electron Beam Cross-linked Polyolefin | |
| | Sheath-Electron Beam Cross-linked Halogen-free Polyolefin | |
| 2) Wire Size; | 4.0 mm ² (AWG 12) | |
| 3) Max. Conductor Temperature; | Continuous; | +110 °C |
| | At Short Circuit; | +250 °C |
| 4) Min. Operating Temperature; | Free Installation; | -25 °C |
| | Fixed Installation; | -40 °C |

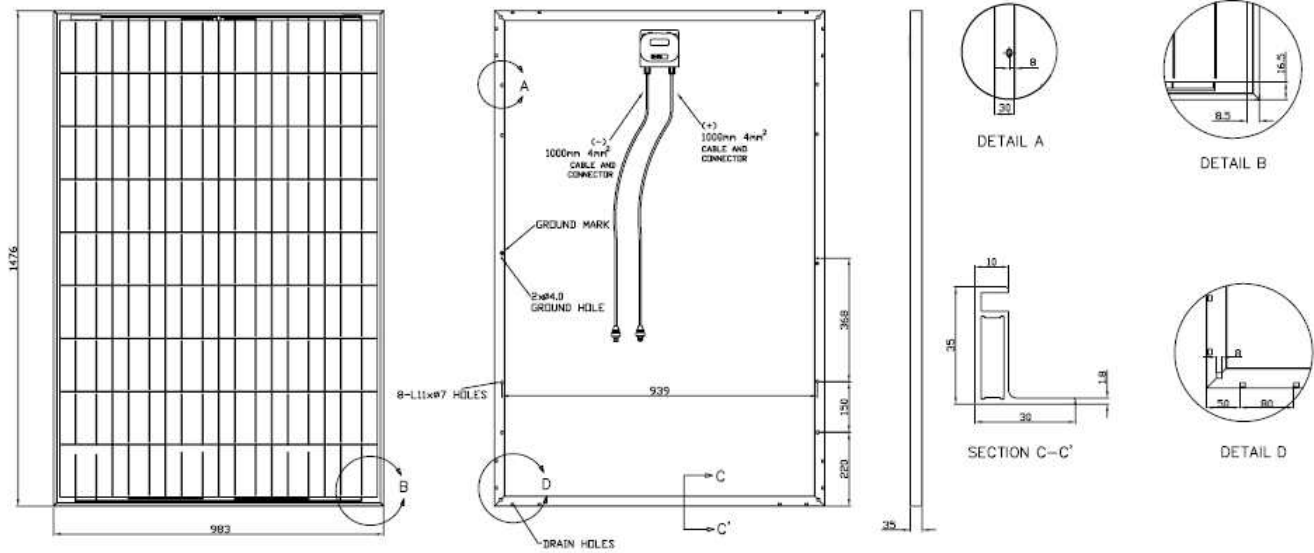
5.7 Conduit

For conduit application, please follow regulations for the outdoor installation of conduits. All fixing parts must protect the conduits from any damage or moisture.

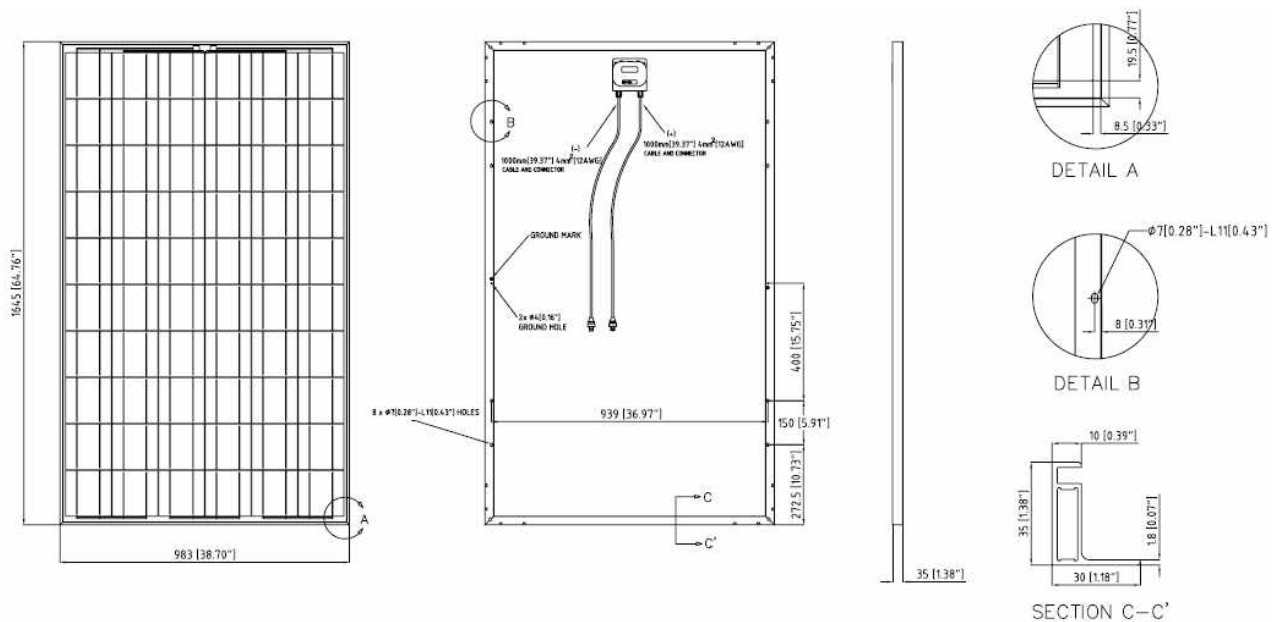
6. Diodes

When there is partial shade on a PV module, reverse current from un-shaded part may flow through the PV module to the shaded part. This phenomenon causes reverse-voltage across the PV module and undesirable heat. Diodes can make the current pass the shaded area, therefore heat and current decrease can be minimized.

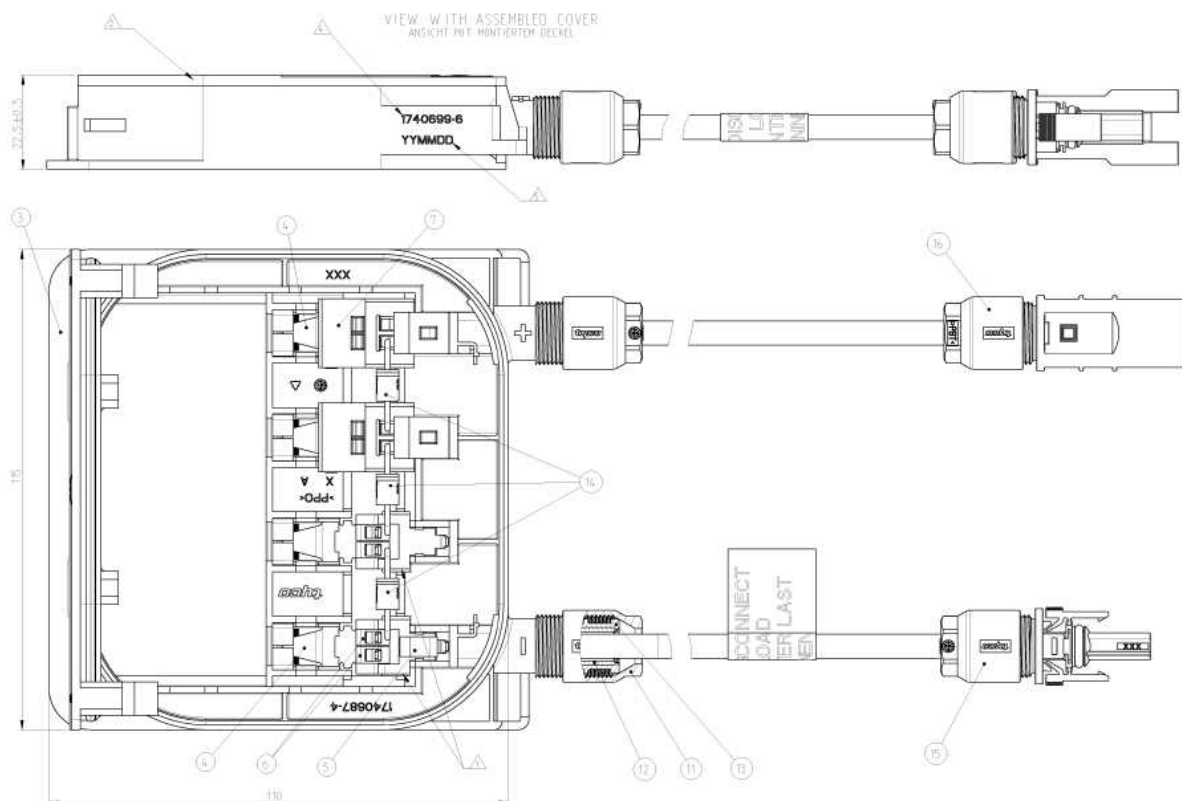
All of HHI's PV modules are equipped with bypass diodes. It is not necessary for users to equip an additional bypass diode because the equipped diodes protect the system circuit within the defined system voltage. If an additional diode is necessary, users must inquire to an authorized engineer of HHI.



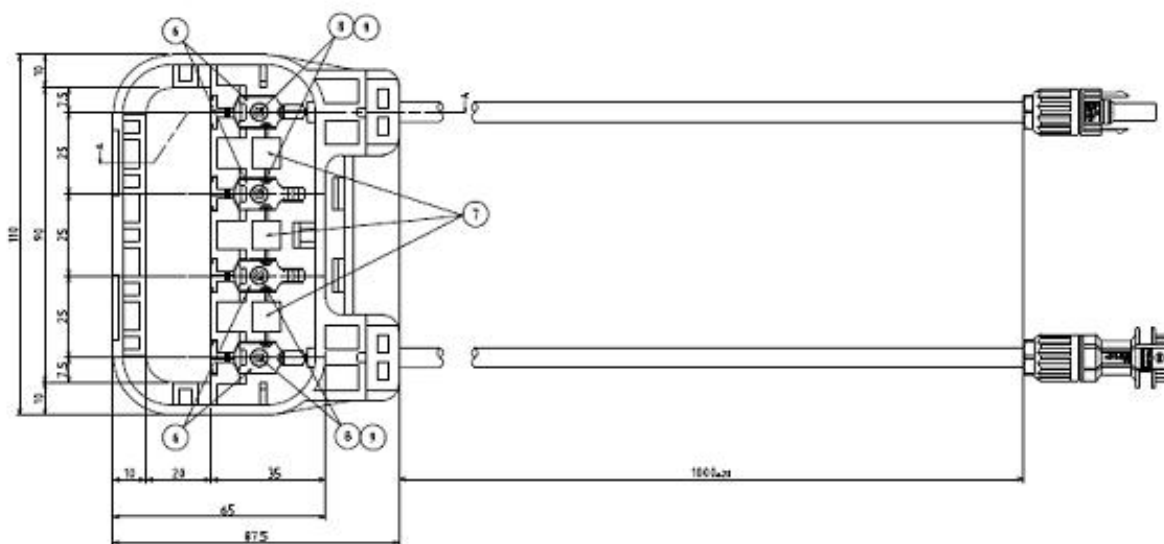
Picture 8. Standard Module Layout & Ground Positions (SF-Series)



Picture 9. Standard Module Layout & Ground Position (SG-Series)



Picture 10. Junction Box (Tyco Electronics)



Picture 11. Junction Box (Yukita Electric Wire)

7. Maintenance

7.1 Troubleshooting

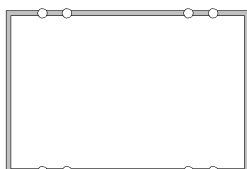
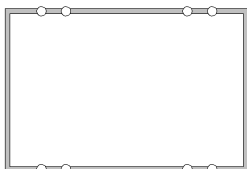
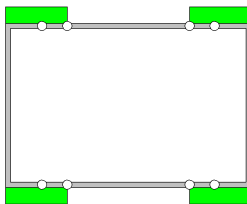
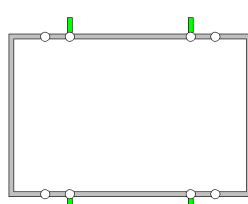
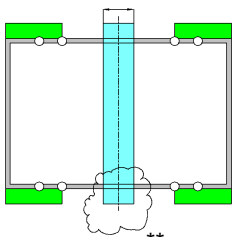
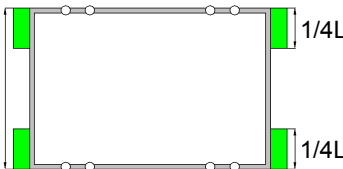
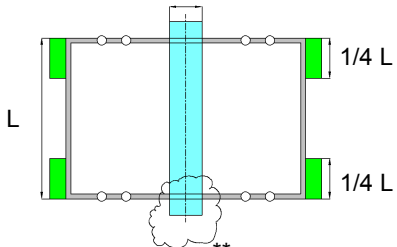
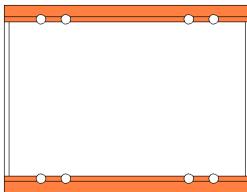
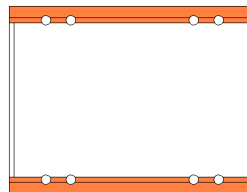


- Module replacement or inspection must be performed after switch-off.
- Maintenance work must be performed in pairs.
- Accessories such as watches, rings and earring must be removed before electrical work.
- All devices and tools must be insulated to prevent any electrical shock or damages.

Problem Type		Solution	Method
Glass Breakage		※ It is recommended to replace the broken module in the early morning or late evening when the module is not generating electricity. In cases where the module is replaced during generation, please follow the instructions below. ① Switch off the junction box of an array which includes the broken module. (If there is no circuit breaker, switch off an inverter instead.) ② After disconnecting the module connectors, replace the broken module. Follow the installation instructions to connect a new module. ③ After replacement, switch on the junction box again.	Visual Inspection
Output Degradation	Surface Contamination	Clean the module surface and remove dirt and contaminants.	Visual Inspection
	Fuse	① Switch off the DC circuit breaker. ② Check fuses of each string from the array showing output degradation. ③ Normal fuse must show resistance 0 at continuity test. Otherwise, the fuse is defected. ④ Replace the defected fuse with a new one. Switch on the DC circuit breaker. ⑤ Measure operating current of the string and check normality.	Multi-Meter, Clamp Meter
	Diode	① Switch off the DC circuit breaker. ② Check diodes of each string from the array showing output degradation. ③ Normal diodes must show voltage between 0.5~0.7 V in the forward direction and 'OL' in the reverse direction. Otherwise, the diode is defected. ④ Replace the defected diode with a new one. Switch on the DC circuit breaker again. ⑤ Measure operating current of the string and check normality.	Multi-Meter, Clamp Meter

Attachment 1. PV Module Installation Instruction

1) Horizontal Installation

Method		2400 Pa	5400 Pa
Bolting O : Mounting Holes	Long -side		
	Long -side		 
	Short -side	 L 1/4 L 1/4 L	 L 1/4 L 1/4 L
Insertion O : Mounting Holes ■ : Insertion Structures	Long -side		

** When additional support structures are installed, it is recommended to install additional clamps on the bottom side of the PV modules to prevent frame slip-off due to heavy snow load.

2) Vertical Installation

Method		2400 Pa	5400 Pa
Bolting O : Mounting Holes	Long -side		
	Long -side		
Clamping O : Mounting Holes ■ : Clamp Location ■ : Additional Support Location	Short -side		
	Short -side		
Insertion O : Mounting Holes ■ : Insertion Structures ■ : Additional Support Location	Short -side		
	Short -side		