

**PAHAL SOLAR
GUJARAT, INDIA**

**SAFETY, INSTALLATION, OPERATION & MAINTENANCE
MANUAL FOR
CRYSTALLINE SOLAR PHOTOVOLTAIC MODULES**

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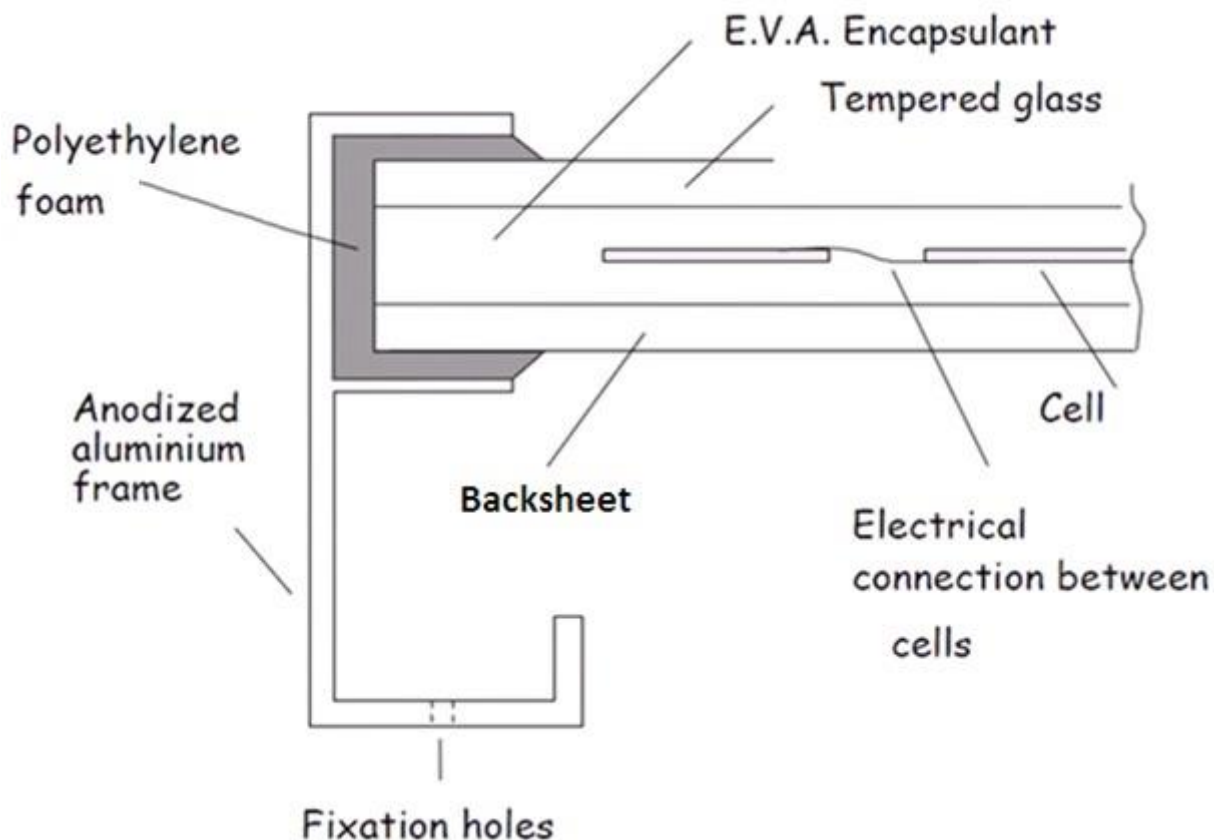
1. General Information

1.1 Introduction

This document provides information for the safe installation and operation of our PAHAL SOLAR photovoltaic module. Carefully read this entire instruction sheet prior to product installation. Information about system sizing, design, safety, and operation are available from your respective distributor. Determine local permit, installation and inspection requirements before installation.

This document is applicable to all PAHAL SOLAR module products. PAHAL SOLAR modules are made of 156.75mm×156.75mm crystalline solar cells in series with high efficiency. The circuit of cells is laminated using E.V.A (ethylene vinyl acetate) as an encapsulant in a set formed by a tempered glass on its front and a plastic polymer (TEDLAR) on the back which provides resistance against environmental agents and electrical insulation. The laminate is inserted into an anodized aluminium structure. The terminal boxes with IP-65 protection are made using plastics that are resistant to high temperatures and contain the connection terminals and the protection diodes (bypass diodes). The frame has various holes in order to attach the module to the support structure, and to its ground-mounting if necessary.

Figure 1 shows a schematic diagram of a cross-section of a photovoltaic module.



1.2 Product Certifications

Products are made according to standards IS IS 14286 & IS 61730-1&2

have passed authority test centre's examination. Our products can be used for rooftop solar systems, PV stations, communication/communication stations, petrol, ocean, meteorological, traffic and solar building etc.

1.3 Disclaimer of Liability

Please follow all relevant Industry Best Practices when handling, installing, and using this product. This guide is designed for use by trained and certified solar professionals only. PAHAL SOLAR. does not assume responsibility for loss, damage or expense resulting from improper installation, handling or use of this product.

1.4 General Safety Reminders

IMPORTANT

THIS PRODUCT IS DESIGNED FOR INSTALLATION BY QUALIFIED PERSONNEL ONLY.

ALL HANDLING AND INSTALLATION MUST BE PERFORMED IN COMPLIANCE WITH ALL APPLICABLE CODES, RULES AND REGULATIONS.

In addition to the applicable rules and regulations, please follow all guidelines for safe handling and/or installation of PAHAL SOLAR modules. In addition to the guidelines below, always observe industry best practices when handling and/or installing any PAHAL SOLAR module.

1.5 Guidelines for Handling and Installation

LIFTING AND HANDLING

- Do not lift the module or carry module by junction box or PV cables.
- Do not drill holes in the frame.
- Avoid scratching the frame. Scratches to the frame will compromise protective coating and can result in corrosion or weakened structure.
- Do not scratch or damage the module Backsheet. Scratches to the Backsheet could affect module performance.
- Do not stand on, drop, scratch or allow objects to hit modules (especially module glass).

- Do not install or handle the modules when wet or during periods of high wind.
- Do not install the modules where there may be flammable gases or vapors, since sparks may be produced.
- Save these instructions for future reference.

ELECTRICAL HANDLING AND INSTALLATION

- **Modules interconnect points conduct direct current (DC) and are sources of voltage when the module is under load and when it is exposed to light**
- **Direct current can arc across gaps and may cause injury or death if improper connection or disconnection is made, or if contact is made with module leads that are frayed or torn.**
- Please use caution when handling any module.
- Remove all metallic jewelry prior to installing this product to reduce the chance of accidental exposure to live circuits.
- Use properly insulated tools to reduce your risk of electric shock.
- Do not touch the terminals while the module is exposed to light.
- During installation use suitable protection prevent a discharge of at least 30 direct current volts to each person on crew.
- Do not connect or disconnect modules when current from the modules or an external source is present.
- Do not remove or misuse module connectors, this could void module warranty.
- Cover all modules in the PV array with an opaque material before making or breaking any connections.
- Use only the supplied locking connectors and safety clips in order to prevent untrained persons from disconnecting the modules once installed.
- There are no serviceable parts within the module. Do not attempt to change or repair any part of the module.
- Damaged modules (broken glass, torn back sheet, broken j-boxes, broken connectors, etc) can present electrical hazards as well as laceration hazards. Contact with damaged module surfaces or module frame can cause electric shock. The dealer or installers should remove the module from array and contact the supplier for disposal instructions.

- The electrical characteristics are within ± 10 percent of the indicated values of I_{sc} , V_{oc} and P_{max} under standard test conditions (irradiance of 100 mW/cm², AM1.5 spectrum and a cell temperature of 25°C)
- Under normal conditions, a Photovoltaic module is likely to experience conditions that produce more current and/or voltage than reported at standard test.
- Conditions accordingly, the values of I_{sc} and V_{oc} marked on this module should be multiplied by a factor of 1.25 when determining component voltage ratings ,conductor capacities, fuse sizes ,and size of controls connected to the PV output.

Refer to section 690-8 of the NEC for an additional multiplying factor of 125 percent (80 percent derating) which may be applicable. Safety Standard for Electrical Installations, please refer to national building codes and safety requirements.

1.7 Installation

Please note the following instructions:

- The module must be installed so that air can freely circulate around it. The cells' working temperature will thus be reduced and, consequently, the module's performance will be enhanced.
- The cross section for the conductors must be ensured that the voltage drop during the installation does not exceed 2% of its nominal voltage.
- PAHAL SOLAR PV modules are supplied with or without cables, according to where they are ordered. Should they be supplied without cables, it is recommended that cables with cross sections between 4 and 10 mm² be used.
- The cables, which allow easy handling while providing high protection against overloads and short-circuits, are formed by flexible Cu conductors, cross linked insulated polyethylene and coated with polyvinyl chloride or similar insulation. The insulation should be flame, acid and alkali resistant and should be stored in an area free of any corrosive gases.

1.8 Warnings

- The modules should be installed and handled by qualified persons only.
- Do not climb up or walk on the module.
- Do not drop the module or throw objects on the module.
- Use the module only for the purpose to which it is designed.
- Do not dismantle the module or remove any part, label, or piece assembled by the manufacturer without the manufacturer's authorization.
- Do not concentrate sunlight or other artificial light sources onto the module.
- Use tools duly coated with insulating material while working with the modules.
- Always work under dry conditions.
- Do not install the modules where there may be flammable gases or vapors, since sparks may be produced.
- Take care to avoid electric discharges when installing, wiring, starting up or carrying out maintenance work on the modules.
- Do not touch the terminals while the module is exposed to light.
- Install with suitable protection to redirect a discharge of 30 or more direct current volts to if delivered any person on the installation team.
- Please prevent adherent of oil such as paraffin liquid, animal oil and vegetable oil from molding parts. It may be cracked or broken and loose the performance of Junction Box and connectors.

2. Operating environment

CLIMATE CONDITION

Install the PV module in the following conditions:

Environment temperature : -20°C to 45°C.

Operating temperature : -40°C to 85°C.

Waterproof: don't put the modules dip in the water or continually explode under the water device or fountain.

Antisepsis: except salt erode and sulfuration places.

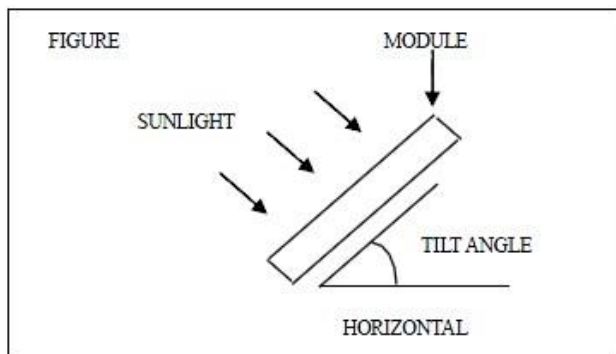
3. Mounting

The module's electrical performances in a system are the same. When connected in series, all modules must have the same amperage. When connected in parallel, the modules must all have the same voltage. Connect the quantity of modules that match the voltage specifications of the devices used in the system. The modules must not be connected together to create a voltage, a voltage higher than the permitted system voltage.

- To minimize risk in the event of an indirect lightning strike avoid forming loops when designing the system.
- Modules must not be fitted as overhead glazing. Ensure that the mounting system can also withstand the anticipated wind and snow loads.
- Precipitation can run off through small openings on the back side of the module. Make sure that the openings are not masked after mounting.
- The maximum load on the module must not exceed 30 lbs/ft² for UL & 5400 Pa for IEC to avoid exceeding the maximum load, site-specific live loads such as wind and snow should take into account. The modules have been evaluated by UL for a maximum positive or negative design loading of 30 lbs/ft².
- The installation of project must be facing the north in the south hemisphere, and facing south in north hemisphere, it will be comparatively lower electricity when the project facing the west or east. The incorrect installation will lead to the losing of the power.
- The modules, which connected in series, must be in same angle; otherwise, it will lose the power because of the differences of sunshine radiation.

Solar modules produce the most power when they are pointed directly at the sun. For installations where the solar modules are mounted to a permanent structure, the solar modules should be tilted for optimum winter performance. As a rule, if the system power production is adequate in the winter, it will be satisfactory during the rest of the year. The module tilt angle is measured between the solar modules and the ground.

Figure 2 shows a schematic diagram of mounted photovoltaic module with tilted angle with respect to latitude.



RECOMMENDED TILT ANGLES FOR A FIXED SYSTEM	
SITE LATITUDE IN DEGREES	FIXED TILT ANGLE
0° TO 15°	15°
15° TO 25°	SAME AS LATITUDE
25° TO 30°	LATITUDE+5°
30° TO 35°	LATITUDE+10°
35° TO 40°	LATITUDE+15°
40° +	LATITUDE+20°

- Must Avoid installing under the shadow, even the module factory use the bypass diode to decrease the loss of energy, but the shadow will lead to losing of output power.

Suitable installation

- Make sure the module meets the technical requirements of the system as a whole. Ensure that other system components do not exert damaging mechanical or electrical influences on the modules when connected in series, modules must all have the same amperage. When connected in parallel, the modules must all have the same voltage. The modules must not be connected together to create a voltage higher than the permitted system voltage, current and power.
- Modules must not be fitted as overhead glazing or vertical glazing. Ensure that the mounting system can also withstand the anticipated wind and snow loads. There are openings at the base of the module frame to allow water from precipitation to drain. Ensure that these openings are not blocked nor partially blocked by the module installation method.
- Artificially concentrated sunlight shall not be directed on the module or panel.

4. Mounting Structure

The modules have been evaluated by UL for mounting using the 4 provided mounting holes in the frame.

Mounting with holes:

- Each module must be securely fastened by screw sets at a minimum of 4 holes (12mm×8mm). The frame has been stress tested for mounting on the long sides. Its short sides must not secure the module.
- We recommend using a torque wrench for installation. The tightening torque (using stainless steel M8 bolts. Stainless steel washer and Stainless steel M8 nut) should be around 15-20Nm. Use the existing holes to secure the module and do not drill additional holes (doing so would void the warranty). Use appropriate corrosion-proof fastening material.
- Clearance between the module frame and mounting surface may be required to prevent the junction box from touching the surface and to circulate cooling air around the back of the module. If the modules are to be installed on the roof, the standoff method is recommended.

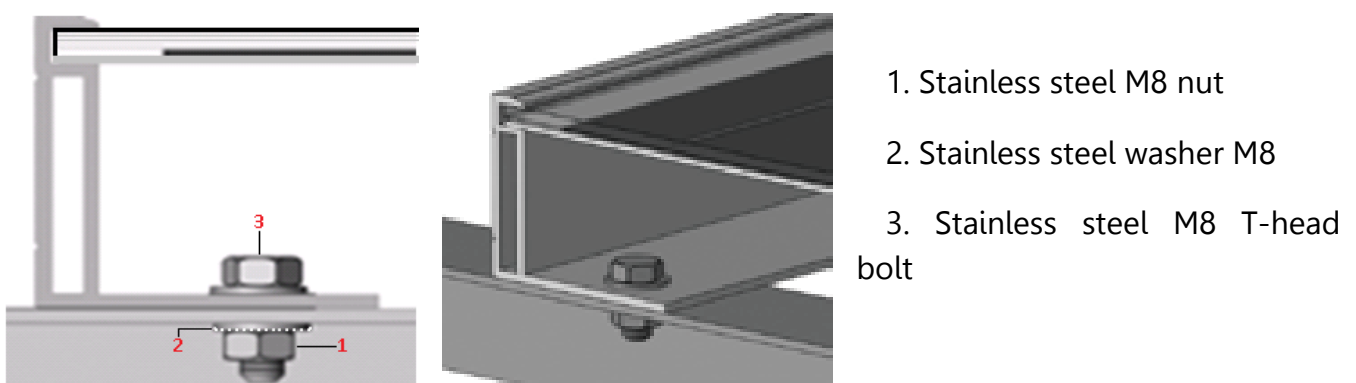
Stand-off method:

- The modules are supported parallel to the surface of the building roof. Clearance between the module frames and surface of the roof is required to prevent wiring damage and to allow air to circulate behind the module. The recommended stand-off height is minimum 50 mm. If other mounting means are employed, this may affect the Listing for Fire Class Ratings.

Screwing:

- Secure the module to the structure using the factory mounting holes. The torque wrench must be used for assembly. In the examples shown, the tightening torque must be 20Nm. Use the existing holes for securing the module; do not drill any additional holes (doing so will void the warranty). Use appropriate corrosion-proof fastening materials.

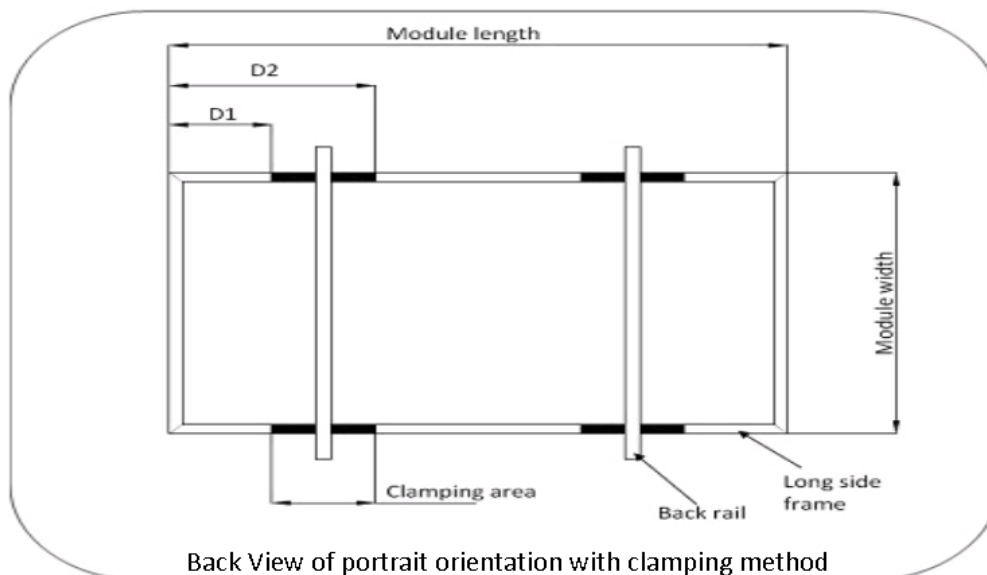
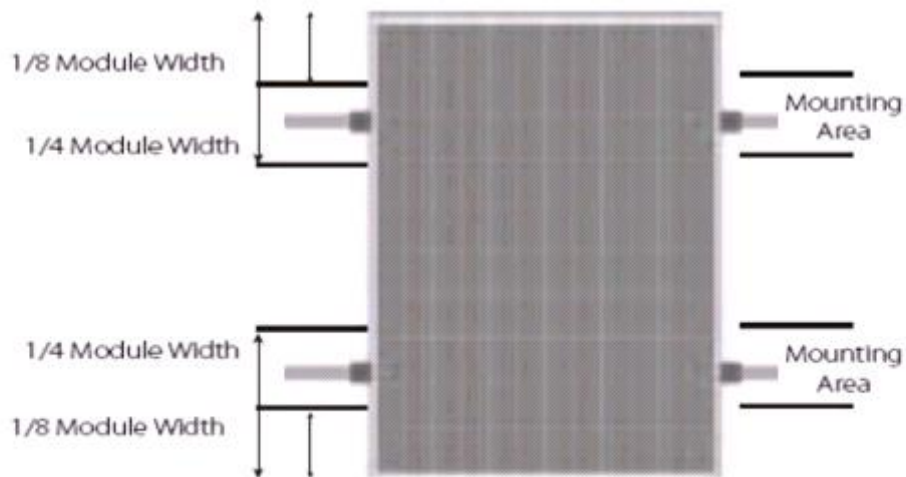
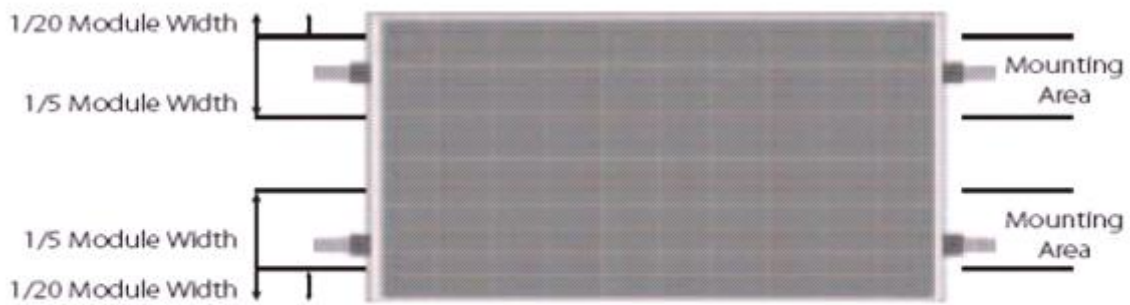
Figure 3 shows a schematic diagram of screwing method for Mounting.



Clamping:

We recommend using the landscape and portrait orientation to install the module, please note the diagram below, when installing:

Figure 6 Mechanical dimensions when modules installed in portrait & landscape orientation with clamping method.



Back View of portrait orientation with clamping method

- The substructure is a supporting frame. It's made of steel. We can install the modules on it. The following picture is the practical example:



5. Grounding(Negative)

Grounding PV modules is necessary and should be always negative to reduce or eliminate shock and fire hazards. The installer of a PV system is responsible for grounding each module frame. It is recommended to ground each module frame at the provided grounding holes. (5 mm diameter, marked with the grounding symbol)

Figure 4 shows a grounding hole and symbol.

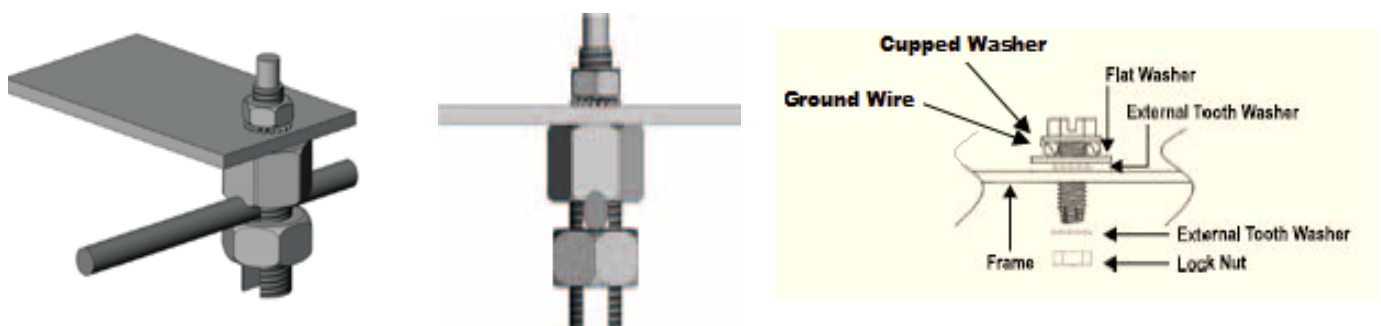


The ground connections between modules must be approved by a qualified electrician. The main earth ground must only be connected by a qualified electrician. UL approved grounding method is mandatory in the USA and Canada. Installation shall be in accordance with CSA C22.1, Safety Standard for Electrical Installations, Canadian Electrical Code, Part I.

Example:

The modules can be connected at the grounding holes using stainless steel nut, bolt, star washer and flat washer of size M5. The torque rating provided for grounding means is 2.3 to 2.8 Nm [20 and 25 in.-lbs]. The grounding method of the frame of arrays shall comply with the NEC, article 250.

Figure 5 shows a diagram of grounding of photovoltaic module.



The grounding screw, bolt or other parts are separately used from the mounting parts of the module. The grounding is achieved through securement to the array frame. The array frame shall be grounded in accordance with NEC Article 250.

6. Wiring

Each module shall be provided with a 15A fuse

The modules use the PVZH009-1 type junction box with cable Photovoltaic wire, type single core 4 sqmm with 90° sunlight resistant rating. This box, on the back side of the module, is weatherproof and is designed to be used with standard wiring or conduit connections. Wiring methods should be in accordance with the NEC (National Electrical Code). Bypass diodes and cable clamps are included with each module when shipped from the factory. The modules have been tested with PVZH009-1 junction box for UL with photovoltaic wire, type PV Wire, 4 sqmm with 90° sunlight resistant rating size has been used for IEC& UL testing. Junction box should be kept in the upper most position in order to avoid the ingress of water.

Correct wiring scheme

- When designing the system, avoid forming loops to minimize risk in the event of an indirect lightning strike. Check that wiring is correct before starting up the generator. If the measured open circuit voltage (Voc) and short-circuit current (Isc) differ from the specifications, then there is a wiring fault.

Correct connection of contact plug connectors

- The plug connector has its own polarity. Make sure that the connection is safe and tight. The plug connector should not receive outer stress. Otherwise, it is only used to connect the circuit!

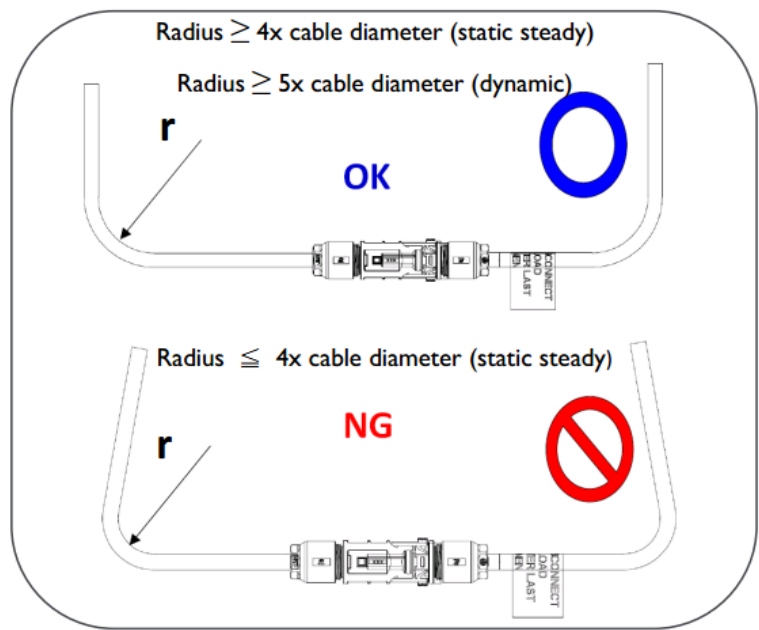
Use of suitable material

- Use cable extensions and plugs that are designed for outdoor application. Ensure that they are in perfect electrical and mechanical condition. Use only cables having one conductor. Select the appropriate cable diameter to minimize voltage drop (to calculate the minimum cable diameter and the fuse, and to calculate controls, multiply the Isc and Voc by a factor of 1.25). The recommended cable size is 12AWG.

Cable Protection

- Secure the cables to the mounting system using UV-resistant cable ties. Protect exposed cables from damage using suitable precautions. Avoid direct exposure to sunlight.
- The cable must not be bent or crushed on the direct exit of the cable screw joint. A minimum bending radius $r \geq 4x$ (static steady), $r \geq 5x$ (dynamic) cable diameter must be maintained. The cable must be routed in a way that tensile stress on the conductor or connection(s) is prevented.

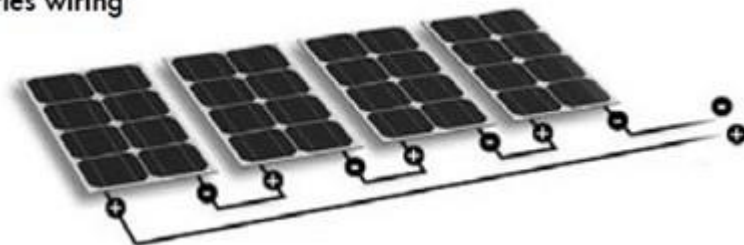
Figure 5 Minimum bending radius of cable.



To get higher current or higher voltage or both, the modules typically shall be connected into an array by field wiring. There are two methods of wiring: series wiring and parallel wiring.

6.1 The series wiring:

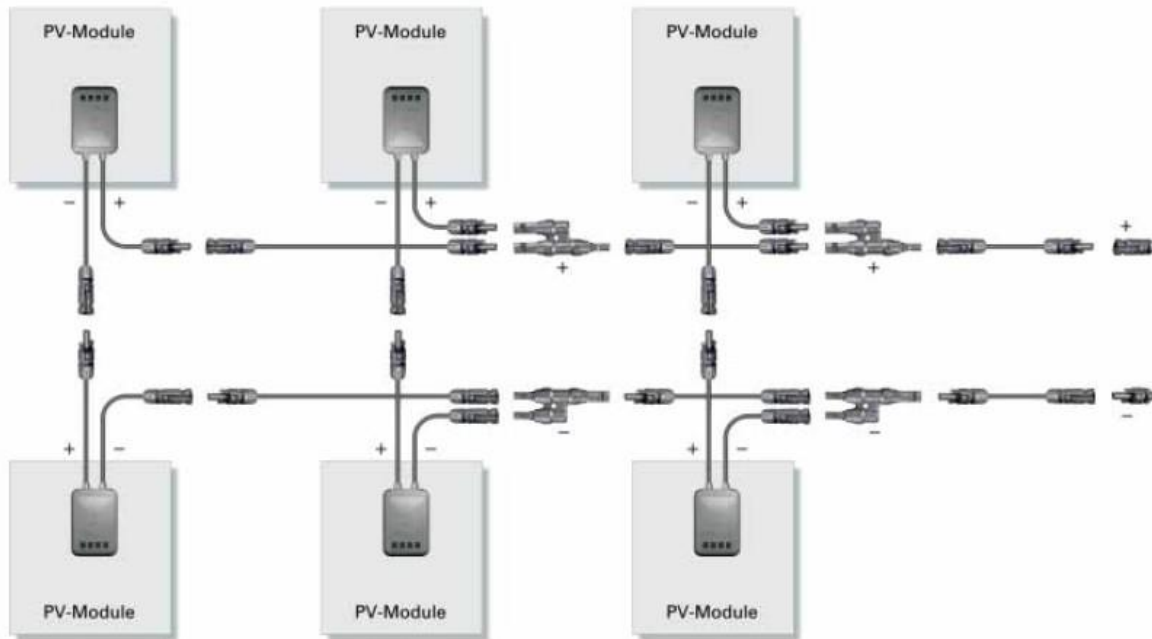
series wiring



6.2 The parallel wiring:

parallel wiring





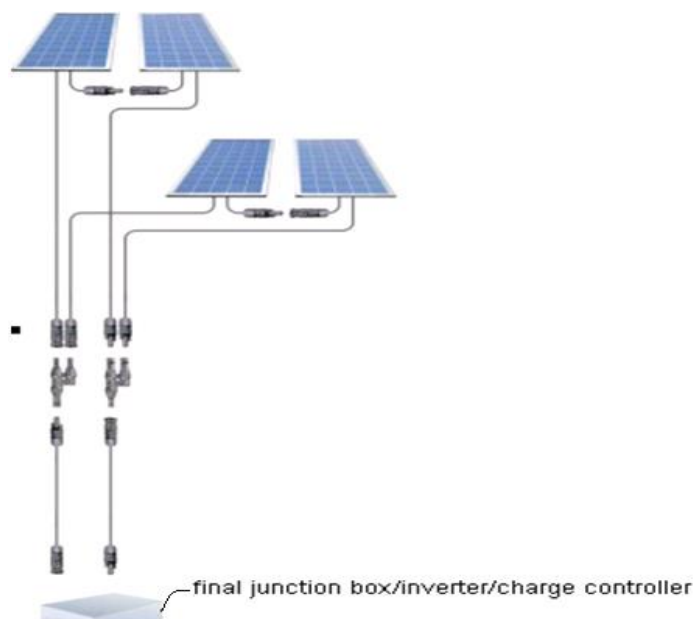
Additional connectors and cables are required to make parallel connection. Connector shall be type MC4 compatible male and female and cable shall be type single core 4 sqmm, TUV 1000 V and UL 1000 V.

For IEC testing the recommended connectors are MC4 compatible male and female, 1000VDC UL and TUV and cables are PV wire type single core 4 sqmm, 1000 VDC from UL and TUV.

6.3 Suggested maximum number of modules in parallel and in series:

- When designing the system, we recommend that the maximum number of modules in parallel should be no more than four while the maximum number of modules in series no more than eight.

6.4 Wiring the array to final junction box/inverter/charge controller:



According to the above picture to make field wiring to final junction box/inverter/charge controller. When additional connectors and cables are used, connector shall be type MC4 compatible male and female and cable shall be type single core 4 sqmm, TUV 1000 V and UL 1000 V.

6.5 Bypass diodes

- Partial shading of an individual module can cause a reverse voltage across the shaded module. Current is then forced through the shaded area by the other modules.
- When a bypass diode is wired in parallel with the series string, the forced current will flow through the diode and bypass the shaded module, thereby minimizing module heating and array current losses.
- Diodes that are used as bypass diodes must: Have a Rated Average Forward Current 20A or above and have a Rated Repetitive Peak Reverse Voltage 45V or above.

6.6 Battery

- When solar modules are used to charge batteries, the battery must be installed in a manner which will protect the performance of the system and the safety of its users.
- The battery should be away from the main flow of people and animal traffic. Select a battery site that is protected from sunlight, rain, snow, debris, and is well ventilated.
- Most batteries generate hydrogen gas when charging, which is explosive. Do not light matches or create sparks near the battery bank. When a battery is installed outdoors, it should be placed in an insulated and ventilated battery case specifically designed for the purpose.

7. Electrical Ratings

The module electrical ratings are measured under Standard Test Conditions (STC) of 1000W/m² at cell temperature of 25°C with Air mass of 1.5 spectrums. PAHAL SOLAR modules deliver specific electrical characteristics as shown in the below table:

PV Module Model Name	Open Circuit Voltage @ STC, (Voc)	Rated Voltage @ STC/Vmp (V dc)	Maximum System Voltage, (V dc)	Rated Current @ STC/Imp (A)	Short Circuit Current @ STC/Isc (A)	Rated Maximum Power at STC, (Watts)	Module Eff (%)	Module Fill Factor (%)	Maximum Series Fuse, (A)
Family Name (72 cell)									
PS315	45.50	37.72	1000	8.34	8.92	315	16.17	77.50	15A
PS320	45.64	38.11	1000	8.39	8.96	320	16.34	78.18	15A
PS325	45.79	38.42	1000	8.45	9.01	325	16.52	78.68	15A
PS330	45.93	38.64	1000	8.54	9.09	330	16.79	79.00	15A
Family Name (60 Cell)									
PS260	37.8	31.4	1000	8.28	8.90	260	15.27	77.20	15A
PS265	37.8	31.59	1000	8.39	8.96	265	16.34	78.20	15A
PS270	38.16	31.88	1000	8.47	9.03	270	16.61	78.33	15A
PS275	38.22	32.2	1000	8.54	9.09	275	16.79	79.02	15A
Family Name (54 Cell)									
PS235	34.07	28.31	1000	8.3	8.90	235	16.08	77.40	15A
PS240	34.23	28.6	1000	8.39	8.96	240	16.34	78.23	15A
PS245	34.45	28.68	1000	8.54	9.09	245	16.79	78.21	15A
PS250	34.55	28.76	1000	8.69	9.22	250	17.24	78.19	15A
Family Name (48 Cell)									
PS210	30.28	25.27	1000	8.3	8.91	210	16.08	77.74	15A
PS215	30.48	25.54	1000	8.41	8.97	215	16.43	78.56	15A
PS220	30.62	25.76	1000	8.54	9.09	220	16.79	79.09	15A
PS225	30.8	26.01	1000	8.66	9.17	225	17.15	79.75	15A
Family Name (36 Cell)									
PS010	22.68	18.18	600	0.55	0.59	10	15.55	72.25	6.5A
PS015	22.68	18.29	600	0.82	0.88	15	15.55	71.10	6.5A
PS020	22.68	18.18	600	1.1	1.19	20	15.99	74.09	6.5A
PS030	22.68	18.18	600	1.65	1.77	30	15.99	74.72	6.5A
PS037	22.82	19.23	600	2.08	2.22	37	16.34	78.95	6.5A
PS040	22.82	19.23	600	2.08	2.22	40	16.34	78.95	6.5A
PS050	22.68	18.18	600	2.75	2.96	50	15.55	76.52	6.5A
PS055	22.96	19.36	600	2.84	3.02	55	16.79	75.31	6.5A
PS075	22.68	18.15	600	4.13	4.44	75	15.55	71.39	12A
PS080	22.82	19.09	600	4.19	4.47	80	16.43	73.61	12A
PS105	22.71	18.98	600	5.53	5.93	105	16.08	77.07	12A
PS110	22.96	19.33	600	5.69	6.05	110	16.79	75.79	12A
PS120	22.82	19.07	600	6.29	6.71	120	16.34	76.17	12A
PS125	22.96	19.53	600	6.4	6.81	125	16.79	75.62	12A

PS155	22.68	18.71	1000	8.28	8.9	155	15.99	77.71	12A
PS160	22.86	19.07	1000	8.39	8.96	160	16.34	78.80	12A
PS165	22.96	19.32	1000	8.54	9.09	165	16.79	78.99	12A
Family Name (18 Cell)									
PS003	11.34	9.09	600	0.33	0.35	3	15.99	75.57	6.5A
PS005	11.34	10.2	600	0.49	0.52	5	15.99	84.75	6.5A

8. Maintenance and cleaning

- Inspect all modules annually for safe electrical connections, sound mechanical connection, and corrosion.
- PAHAL SOLARPV module may use anti-reflective coating (ARC) glass to enhance power output.
- Do not touch glass surface unless wearing clean gloves in order to prevent fingerprints or smudges on the ARC. Fingerprints may be removed with standard glass cleaner.
- Periodically clean glass and the module surface only with a soft cloth or sponge using mild detergent and water.
- Do not use harsh cleaning materials such as scouring powder, steel wool, scrapers, blades, or other sharp instruments to clean the glass surface of the module. Use of such materials will void the product warranty.

8.1 Module Cleaning Guidelines and Instructions

- Dirt piled up on the module's transparent surface reduces its performance and may cause the module hot spot effect. This problem may become serious in the case of industrial waste and bird droppings collecting on the module surface.
- Thin layers of dust (normal soiling) that reduce the sun's intensity evenly are not dangerous and the power reduction is not as significant as other debris.
- Clean the module array regularly to address reduced production due to soiling. The frequency of cleaning depends on how quickly material accumulates. Mounting the module at or above a 15 degree angle will help prevent dust and debris from collecting on the module.
- In many cases, rainfall may reduce or remove the need to clean the modules. It is best to clean the module during early morning, late afternoon or cloudy day. Do not clean module during high temperature, temperature lower than zero degrees Celsius, or any time when there is a large temperature difference between module and cleanser.
- If it is necessary to clean back side of module, do not damage any components. Avoid allowing any oily liquids such as paraffin liquid, animal oil, or vegetable oil contacting with junction box, cable and connector. PAHAL SOLARPV modules can withstand snow pressure

of 5400Pa(IEC)&30 lbs/ft² (UL 1703). Please use soft brush lightly removing snow pileup. Do not try to remove frozen snow and solid ice on the module (it will eventually melt off).

Solution Mixture: Clean water with low mineral amount, non-abrasive/ non-caustic detergent, weak acid/weak alkaline solution, or solution of PH < 10. Do not use high pressure spray.

Cleaning Tool: Soft brush, non-conductive brush, non-abrasive sponge, non-abrasive cloth, seamless cloth.

- Clean module and glass surface with solution and tool described as above.
- If dirty area on glass surface which is hard to be cleaned such as oily substances, try to use commercial glass detergent, alcohol, isopropanol (IPA), or sodium bicarbonate solution.
- Use clean water to rinse glass clean of all cleaning solution. Dry wet modules using a clean and dry cloth. Do not leave stagnant water on glass surface.

8.2 Cleaning the Frame

- PAHAL SOLAR module frames include an anodic oxide coating to increase produce life. The cleaning cycle for regular anodic oxide coatings is generally every six months. When cleaning, be sure not to damage or scratch this coating.
- Dirt can generally be cleaned off using a suitable lubricant or warm, mild soapy water, and a fiber brush may be used to clean any dust that may also stick to the surface. Do not use abrasive cleaning tools like steel wool or acidic/ alkaline chemicals to clean.

8.3 Visual inspection of the module

During regular cleaning cycles, be sure to visually inspect each module. The purpose of visual inspection is to detect possible faults or damage. Specifically:

- Possible broken glass.
- Rust on the circuits and soldering of the PV cells. Normally this is due to moisture entering the module through a breakage in the encapsulating layer during installation or transport.

8.4 Inspecting connections and cabling

While performing preventive maintenance every 6 months, carrying out the following operations:

- Check the tightness and condition of the connection cable junctions.
- Check the junction box sealing. Should sealing faults be observed, the items which have been affected should be replaced and cleaned. Contact PAHAL SOLAR for additional information about resolving faults in module seal.

9. Storage and transportation

- When storing modules for any period of time, cover modules to ensure protection from the elements.
- When storing the modules, turn so that the glass is face down. Do not allow water to collect inside module, this can damage module connectors.
- When storing the modules, do not allow the anodized profiles (frames) to come into contact with contaminants such as cement or mortar, which will cause damage to the anodic oxide coatings.

Always contact your module supplier for additional instructions if maintenance is necessary.

