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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.

The Installation manual is applicable for both 1500V & 1000V series modules. It is recommended to check & get a confirmation from the manufacturer on the rated system voltage of the product before using the panels.

2. SAFETY MEASURES

2.1 WARNINGS

Before installing, wiring, operating, or maintaining Trina modules, you should read and understand all safety precautions. Direct current (DC) is generated when the battery surface of the module is exposed to direct sunlight or other light sources, and direct

contact with the live parts of the module, such as terminals, may result in death of personnel whether connected to the module or not.

3. GENERAL INFORMATION

PAHAL SOLAR modules convert the energy of light directly into continuous/direct current (DC) by the photovoltaic effect.

PAHAL series consisted of different modules in the sense of cell number, contact technology, and module size.

3.1 MODEL NAMING OVERVIEW:

PAHAL SOLAR
INSTALLATION MANUAL

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 (%)	Module Matrix	Module Dimension (mm)		
										T	W	H
Family Name (144 Cell - Half Cut) (182*91)												
PS_550	49.81	41.87	1500	13.14	14.00	550	21.30	78.90	2*(12*6)	2278	1134	35
PS_545	49.61	41.62	1500	13.10	13.94	545	21.11	78.83	2*(12*6)	2278	1134	35
PS_540	49.41	41.36	1500	13.07	13.89	540	20.92	78.76	2*(12*6)	2278	1134	35
PS_535	49.21	41.10	1500	13.03	13.83	535	20.73	78.68	2*(12*6)	2278	1134	35
PS_535	49.04	40.94	1500	12.95	13.76	530	20.53	78.58	2*(12*6)	2278	1134	35
PS_525	49.16	41.29	1500	12.73	13.63	525	20.35	78.45	2*(12*6)	2278	1134	35
Family Name (132 Cell - Half Cut) (182*91)												
PS_500	45.47	38.03	1500	13.10	13.85	500	19.36	79.37	2*(11*6)	2278	1134	35
PS_495	45.36	37.92	1500	13.05	13.81	495	19.16	79.03	2*(11*6)	2278	1134	35
PS_490	45.24	37.80	1500	13.01	13.77	490	18.97	78.68	2*(11*6)	2278	1134	35
PS_485	45.04	37.53	1500	12.93	13.68	485	18.77	78.72	2*(11*6)	2278	1134	35
PS_480	45.07	37.53	1500	12.79	13.61	480	18.58	78.29	2*(11*6)	2278	1134	35
Family Name (120 Cell - Half Cut) (182*91)												
PS_460	41.5	34.435	1500	13.36	13.97	460	17.81	79.34	2*(10*6)	2278	1134	35
PS_455	41.39	34.315	1500	13.26	13.90	455	17.61	79.10	2*(10*6)	2278	1134	35
PS_450	41.27	34.195	1500	13.16	13.83	450	17.42	78.84	2*(10*6)	2278	1134	35
Family Name (144 Cell - Half Cut) (166*83)												
PS_445	49.41	41.39	1500	10.75	11.42	445	20.38	78.86	2*(12*6)	2100	1040	40
PS_440	49.23	41.13	1500	10.71	11.36	440	20.15	78.67	2*(12*6)	2100	1040	40
PS_435	49.06	40.87	1500	10.67	11.30	435	19.92	78.48	2*(12*6)	2100	1040	40
PS_430	48.89	40.61	1500	10.63	11.24	430	19.69	78.28	2*(12*6)	2100	1040	40
Family Name (132 Cell - Half Cut) (166*83)												
PS_415	45.29	37.94	1500	10.94	11.40	415	19.00	80.38	2*(11*6)	2100	1040	40
PS_410	45.13	37.70	1500	10.87	11.32	410	18.77	80.25	2*(11*6)	2100	1040	40
PS_405	44.97	37.46	1500	10.81	11.24	405	18.54	80.12	2*(11*6)	2100	1040	40
PS_400	44.81	37.22	1500	10.75	11.16	400	18.32	79.98	2*(11*6)	2100	1040	40
PS_395	44.65	36.98	1500	10.69	11.08	395	18.09	79.84	2*(11*6)	2100	1040	40
Family Name (132 Cell - Cut Cell) (157X83)												
PS_380	44.39	38.39	1500	9.90	10.20	380	19.53	83.92	2*(11*6)	1965	990	40
PS_375	43.96	38.02	1500	9.86	10.10	375	19.28	84.47	2*(11*6)	1965	990	40
PS_370	43.52	37.64	1500	9.83	10.00	370	19.02	85.02	2*(11*6)	1965	990	40
PS_365	43.09	37.26	1500	9.80	9.90	365	18.76	85.58	2*(11*6)	1965	990	40
PS_360	42.65	36.89	1500	9.76	9.80	360	18.51	86.15	2*(11*6)	1965	990	40
Family Name (120 Cell - Cut Cell) (157X83)												
PS_350	40.75	35.24	1500	9.93	10.28	350	18.00	83.57	2*(10*6)	1965	990	40
PS_345	40.36	34.90	1500	9.89	10.18	345	17.74	83.99	2*(10*6)	1965	990	40
PS_340	39.96	34.56	1500	9.84	10.08	340	17.48	84.41	2*(10*6)	1965	990	40
PS_335	39.56	34.22	1500	9.79	9.98	335	17.22	84.84	2*(10*6)	1965	990	40
PS_330	39.17	33.88	1500	9.74	9.88	330	16.97	85.28	2*(10*6)	1965	990	40
Family Name (108 Cell - Cut Cell) (157X83)												
PS_310	36.68	31.72	1500	9.78	10.20	310	15.94	82.92	2*(9*6)	1965	990	40
PS_305	36.32	31.41	1500	9.71	10.10	305	15.68	83.16	2*(9*6)	1965	990	40
PS_300	35.96	31.10	1500	9.65	10.00	300	15.42	83.42	2*(9*6)	1965	990	40
PS_295	35.61	30.80	1500	9.58	9.90	295	15.16	83.68	2*(9*6)	1965	990	40

3.2 Electrical Specifications

The performance and all photovoltaic parameters of the modules are measured under two different conditions:

(1) Standard Test Conditions (STC)

(2) Normal Operating Cell Temperature (NOCT).

Detailed electrical characteristics for all PV modules are presented in our products' DATASHEET and [www. Pahalsolar.com](http://www.Pahalsolar.com)

4. DISCLAIMER OF LIABILITY

regard,
either expressly or implicitly, or under any patent rights.

Information contains in this instruction manual is based on PAHAL SOLAR Information and expertise.

The company can change this manual and specification without giving any prior information. PAHAL SOLAR has rights to amend this document any time including PV module specification without prior notification.

5. PRODUCT CERTIFICATIONS

stations, communication/communication stations, petrol, ocean, meteorological, traffic and solar building etc.

6. LIMITED WARRANTY

Please refer to PAHAL SOLAR WARRANTY DOCUMENT. Of Sale for details of the module's limited warranty. Failure to comply with this Safety and Installation Manual would void PAHAL SOLAR Warranty for the PV modules as stated in the General Terms and Conditions of Sale.

PAHAL SOLAR assumes no responsibility for th

7. MODULE SPECIFICATION

Please refer to the appropriate DATASHEETS for electrical performance data and mechanical installation information.

8. STORAGE UNPACKING & HANDLING OF PV MODULE

8.1 Forklift handling precautions

- In the process of loading and unloading, the forklift should be selected reasonably according to the size and weight of the goods. If the fork length is less than 3/4 of the size of the goods extension sleeves should be fitted on the forks before the assembly is forked, to avoid the packing container dumping when moving the forklift.
- When the forklift is loaded with modules, the spacing between the two forks should be adjusted as required. The load of the two forks should be balanced without deflection. One side of the assembly box should be close to the retainer (Figure 1)



(Figure 1)



(Figure 2)

- Loading and unloading process, except forklift operator, others should be kept at a safe distance from range, ensure the safety of personnel.



- During loading and unloading, special command is required to avoid failure and making modules down.
- When using a forklift to move palletized packing boxes to the operation area, the forklift shall be slowly and steadily lifted and put down gently during loading and unloading, and the modules shall avoid turbulence and violent vibration during transportation

8.2 Attention in loading and unloading with hoisting/Crane

- The hoisting rope of crane unloading needs to choose a longer nylon sling, wire rope is not allowed to use (Figure 3).
- Before lifting, the length of the sling should be evenly distributed on both sides to avoid the case body tilting to one side during lifting, which causes the sling to be too tight and the assembly to explode.
- When lifting, the box should be kept balanced to avoid module tilting.
- When someone is required to direct the hoisting box to fall during unloading, it shall be kept as flat as possible to avoid collision and throwing of the module box, and the ground shall be flat (Figure 4)



(Figure 6)

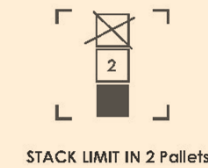
(Figure 7)

(Figure 3)

(Figure 4)

8.3 Storage Guidelines

- Due to the complex environment and climate of the project site, it is recommended to store the stacked modules with single support after dismantling in order to ensure the safe storage of the modules on site (Only after cutting the outer packing belt of the connecting two brackets, separate the upper and lower brackets),The double glass modules should be stored with single support after dismantling.
- modules should be stored in a complete outer package, and the storage area should be protected and pallets and packing cases from damp, direct sunlight and waterproof (rain) measures.
- The modules storage areas should be kept dry, level, the ground and the horizontal Angle is less than 10 °
- Make sure that all modules with the same current gear are installed in the same area centrally (Square matrix, bus box).



8.4 LIFTING,HANDLING & ELECTRICAL INSTALLATION

- Do not expose the modules to artificially concentrated sunlight.
- Do not stand on, drop, scratch, or allow objects to fall on the modules.
- Do not drill holes in the frame. It may compromise the frame strength
- Do not lift the modules by the junction box or junction box cables.
- 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 vapours, since sparks may be produced.
- Do not leave cable connectors exposed in adverse climatic conditions. Water and dust deposits inside the cable connectors can cause long-term damage.
- Ensure that junction box cables are provided with strain relief to avoid damage to the junction box, maintaining a minimum bending radius of 50 mm at all locations along the cable.
- **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.
- 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.
- For modules under IEC investigation, under normal conditions, a solar photovoltaic module is likely to Experience conditions that produce more current and/or voltage than reported at standard test.
- Conditions accordingly, the values of Isc and Voc 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.
- Rated electrical characteristics are within the production tolerance of measured values at Standard Test Conditions of 1000 w/m², 25°C±2

cell temperature and AM 1.5 solar spectral irradiance. According to IEC 60904-3.

- 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 vapours, 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 form molding parts. It may be cracked or broken and loose the performance of Junction Box and connectors.

9. MODULE IDENTIFICATION

Each module has a unique serial number, which is laminated behind the glass. Please do not tamper with the serial number of the module and always record the serial numbers during an installation for your future records. A nameplate containing model name, electrical and safety characteristics of the module are also affixed to the backside.

BE AWARE

Bifacial modules increase energy and power production respect to STC nominal data through Albedo on rear surface. Refer to the specific area on data sheet for real parameters expected after installation to calculate correctly inverter, cables and connection size.

10. ENVIRONMENTAL CONSIDERATIONS

10.1 Climate Conditions

All PAHAL SOLAR modules are tested for IEC 61215, IEC 61730-I & II, UL 1703, IEC 61701, IEC 62716, IEC 62804. The modules are qualified for application Class A. Modules qualified for safety through IEC 61730 within this application class is considered to meet the requirements of Safety Class II. PAHAL SOLAR PV modules meet the requirement of European standards as they are also tested for the Ammonia fumes that may be present in Barns sheltering Cattle, Pigs, as well as sustainability for Installation in Humid (Coastal) Areas of high Sand Storms. PAHAL SOLAR module Passed in testing of Salt mist IEC 61701 Salt mist corrosion test (Severity VI) with a salt concentration of 5% by weight, galvanic corrosion can occur between the aluminium frame and mounting or ground materials if such materials are made of dissimilar metals. Stainless steel and aluminium metal's direct contact is not recommended for seaside installations to avoid metal corrosion.

Environmental Condition

Ambient temperature: -40°C to +50°C.

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

Storage temperature: -20°C to +50°C.

Humidity: ≤85 RH%

Design Load: 800Pa and 1800 Pa Safety Factor: 3 Mechanical Load Pressure: 5400Pa (112.8lb/ft²) from front and 2400 from the rear (50.12lb/ ft²).

Stability of structure

Structure matching the mounting hole pitch of different types of modules is used to survive the load required and fatigue of the outdoor application. The structure should be coated to survive in external environment till lifecycle of PV module of 25 Years. Please consult the PAHAL SOLAR technical support department for more information on the use of modules in special climates, , such as an altitude greater than 2000 m. Important instruction for Mounting

- Always avoid loop formation during designing, to minimize the risk during indirect light striking.
- Confirm mounting system must withstand the Loads of wind & and snow should not cross the maximum rated load bearing capacity of PV module that is 2400 Pa for wind and 5400 Pa for snow. PAHAL SOLAR advices the customer to choose the modules carefully considering the environmental conditions.
- Modules are evaluated by third party lab for max. positive loading of 5400 Pa.
- Module installation in projects must face north while being installed in the southern hemisphere and the modules should be south facing while being installed in the northern hemisphere. Electricity generation reduces when the module installed at site facing west or east. Failure to follow this instruction will lead to lesser power generation.
- When the modules are connected in series, the angle at which it is installed should be the same for all the modules. If modules in series connected system are installed at different angles, the radiation of sun becomes uneven which will result in different fluctuating current across the string and will lead to loss in Power Output.
- PV module facing directly to sun produces more power. When solar modules are installed on permanent structure it is recommended to tilt the PV modules for optimum performance during winter season. Measurement of tilt angle done

between the solar module and the ground. Recommended Tilt Angle for a fixed system is listed below.

- PV modules should not be installed under shade or shadow under any conditions as it may lead to current mismatch across the solar cells leading to damage of the solar module. Shadow on the solar module is only acceptable if the irradiation is lesser than 200 W/m².
- ***Never disconnect module cables when it is connected with load.***

11. SITE SELECTION

PV modules should be installed in a place where no shading occurs throughout The year. Shading can be minimized by ensuring that the distance between an obstruction and the solar array is more than three times the height of the Ostruction.

- PV module can be installed in portrait or landscape orientation, impact of dirt shading can be minimized by orienting the PV modules in portrait. The module facing should be south in northern hemisphere and north in southern hemisphere.
- Sufficient row to row gap has to be chosen and PV modules should be spaced between two rows appropriately such that no shadows appear on the PV module at any part of the day during 365 days due to inter row spacing.
- For optimum energy production, solar modules should normally be mounted facing the equator at an angle to the horizontal plane equivalent to the latitude of the installation. If the PV module is placed at a different angle or orientation, this could have a direct impact on the power output.
- To maintain the fire class rating any slope of 1: 2.4 is required.

- Do not use mounting methods where drainage holes are blocked.
- At any condition PV module should not be installed by immersing the module under water.
- PV module should not be installed on moving objects like vehicle or vessel.
- PAHAL SOLAR module is fire rated with Type 1 for Class C.

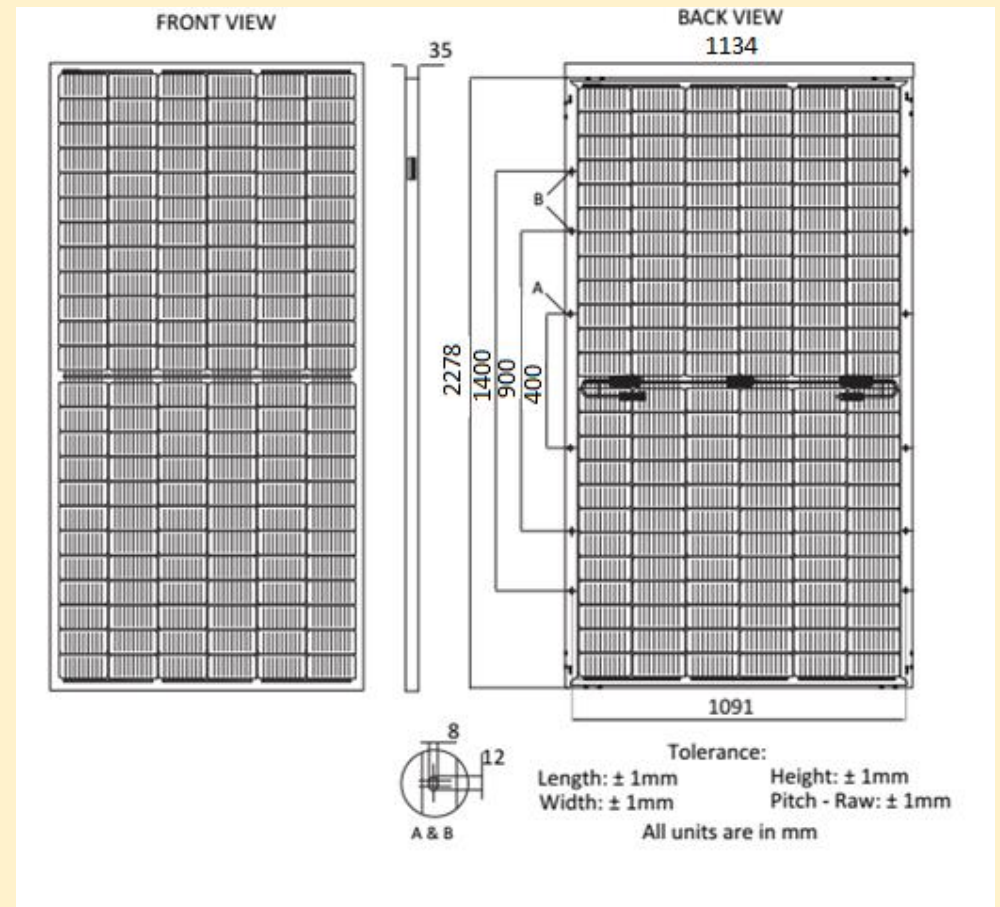
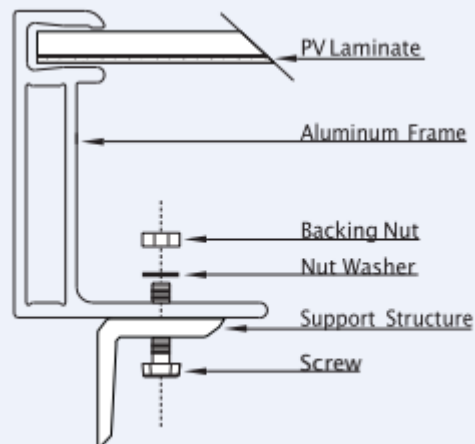
12. **MOUNTING INSTRUCTION**

- Modules should be firmly fixed in place in a manner suitable to withstand all expected loads, including wind and snow loads. Module mounting holes are provided for easy installation and proper mechanical loading.
- The Modules shall be mounted so that the junction box remains in the uppermost position to minimize the ingress of moisture/water.
- Appropriate material should be used for mounting hardware to prevent the Module frame, mounting structure etc. from corrosion.
- Do not install PV modules in a location where they will be immersed in water or continually exposed to water from a sprinkler or fountain, etc
- We recommend leaving a space of at least 10mm~10.5 mm between two Modules considering linear thermal expansion of the Module frames.
- Clearance between the Module frame and the mounting surface is required to allow cooling air to circulate around the back of the Module. This also allows any condensation or moisture to dissipate. The Module should never be sealed to the mounting surface with sealant that prevents air from circulating under the Module. For roof mounted systems, provide adequate rear ventilation (100mm: 4inch gap minimum) for cooling of Modules.
- Always abide by the instructions and safety precautions included with the Modulo. The mounting structure and all hardware like bolts, nuts and washers should be of stainless steel so as to eliminate the possibility of rust.
- When installing a free standing ground mounted system, be sure to select the appropriate height of the support Module mounting structure. It is also

important to select the appropriate height of the mounting system to prevent the lowest edge of the Module from being covered by snow for a long time in areas that experience heavy snow fall .If snow settles on the PV modules regular cleaning of snow and other foreign particles are highly recommended for long term reliability of the PV modules. failure to comply may result in damage of the module resulting in deformation and not covered under warranty.

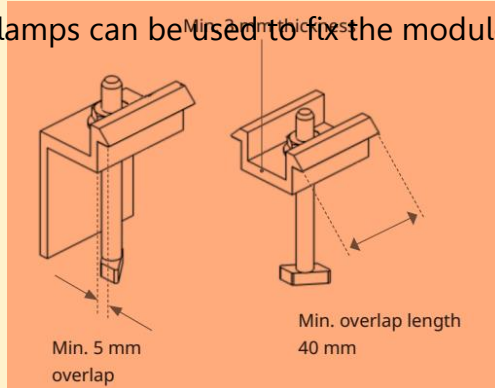
12.1 Bolt Type Fixing

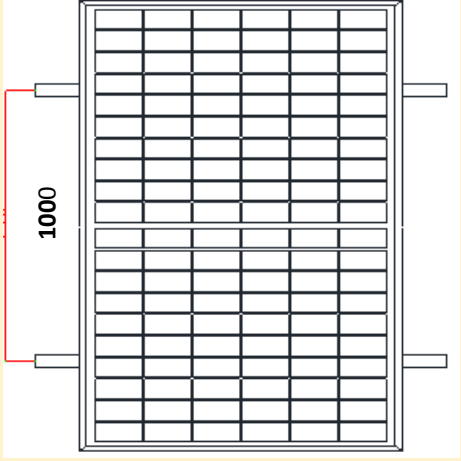
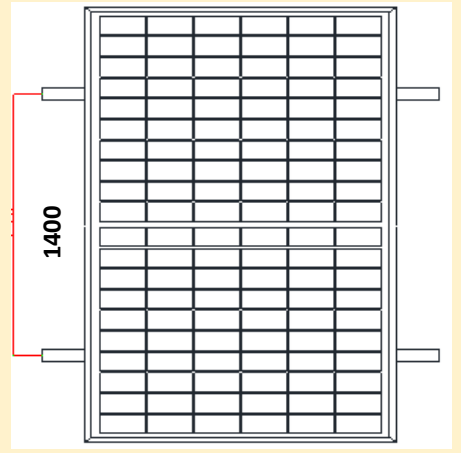
Every module frame contains 8 mounting holes of 8 mm X 12mm. It is recommended from PAHAL SOLAR to use corrosion resistance stainless steel fixing. The module fixed with the support of M8 bolt, washer and nut. For reference please see the below image. The assembly of M8 bolt, nut, washer and the PV module should be tightened to a minimum torque of 16-25 Nm.



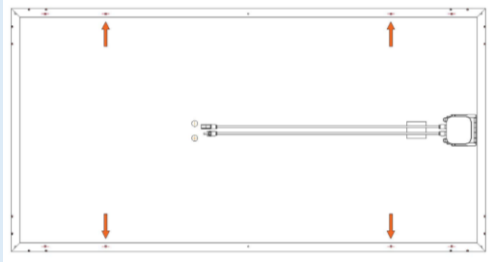
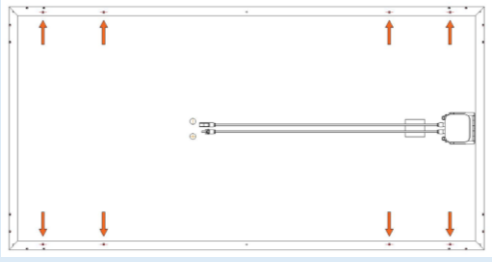
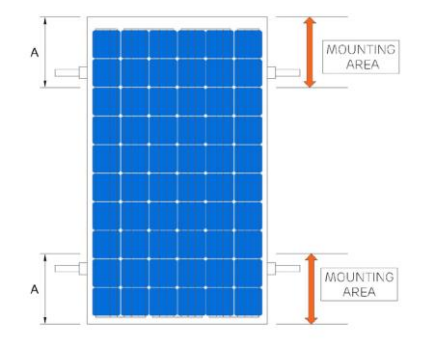
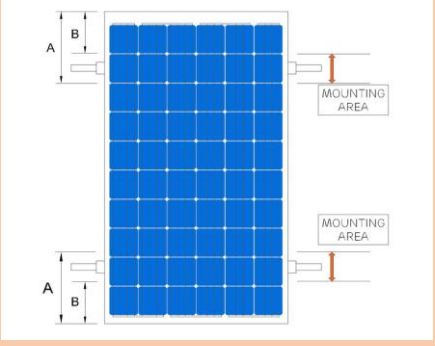
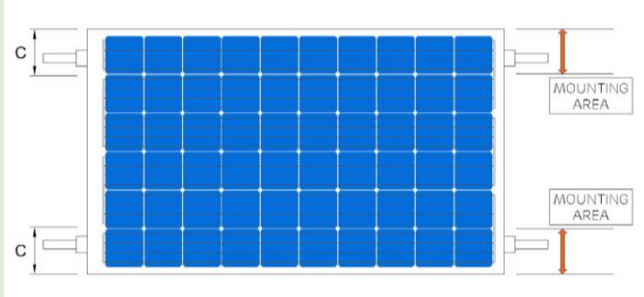
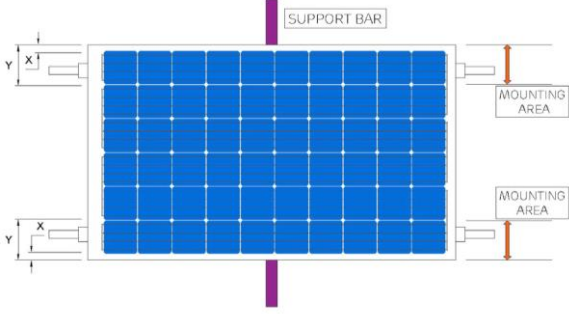
12.2 Clamp Type Fixing

- PAHAL SOLAR has done number of tests on clamps and on the basis of that test results, it is recommended to use clamps with EPDM or with insulating type washer only.
- Total 4 numbers of clamps are required to fix the PV module on structure or mounting rail.
- To avoid any kind of breakage of glass, clamps should not touch the glass and the shadow of clamp should not come on the module front surface.
- No modification or changes in the structure of module frame is permissible.
- When modules fixed with clamp type fixing method, 4 clamps are required to fix the module, 2 clamps on each long side frame and 2 clamps on each short type frame side. PAHAL SOLAR modules are certified for bearing 2400 Pa wind load and 5400 Pa snow load on the front side of the PV module. To bear this load more number of clamps can be used to fix the module



Module	Mechanical Load Pressure	Mounting Direction
60/120 Backsheet-Glass	+3600 Pa /- 1600Pa	
72/132/144 Backsheet-Glass	+3600 Pa /- 1600Pa	

**Mounting Methods and Applies to all
144,72, & 60 Cell PV Modules.**

Mounting Methods	At 2400 Pa load condition	At 5400 Pa load condition
Bolt type Fixing		
Long Side Clamping		
Short Side Clamping		

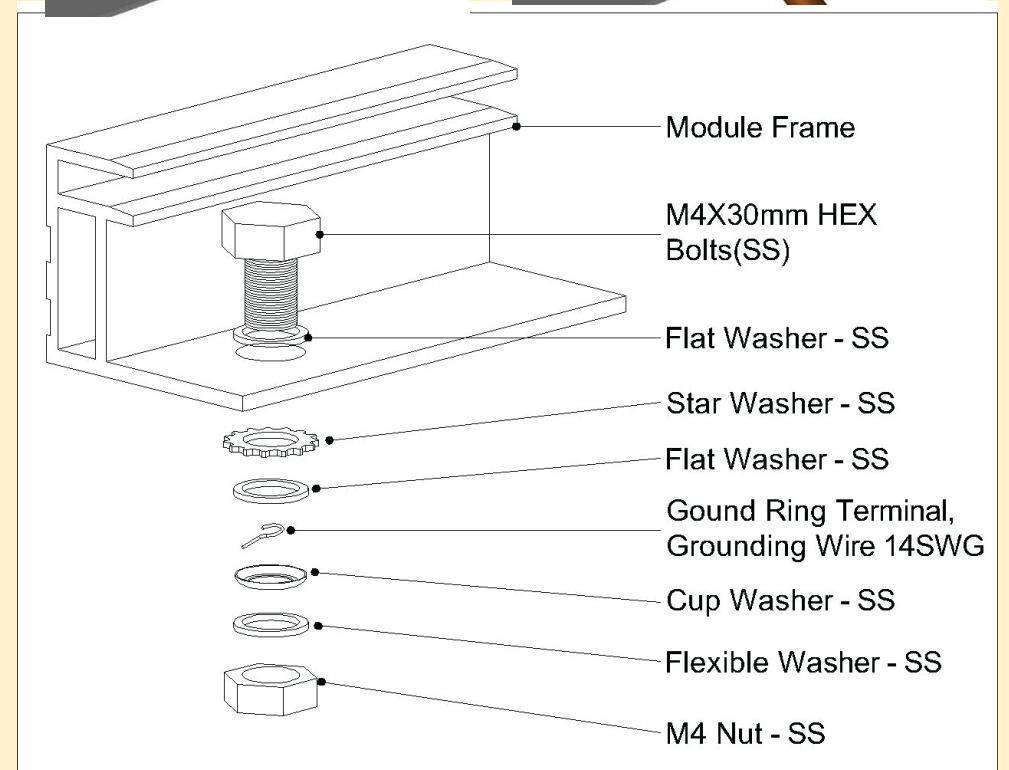
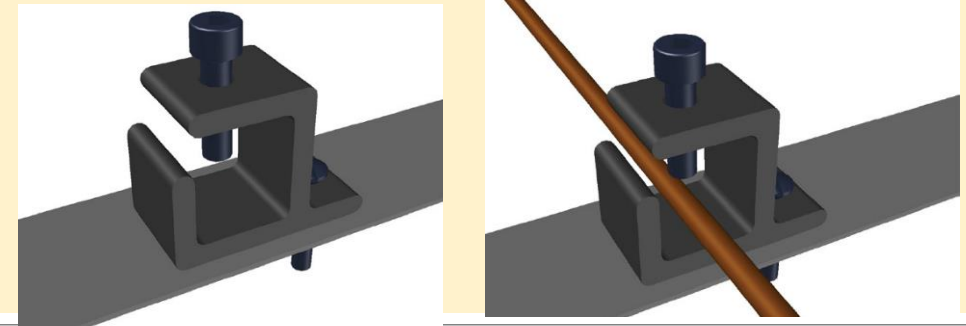
Different Mounting Configurations can be tried as per Installer's calculations, but however failure to comply with the above suggestions may result in a lowering of load handling capabilities and may lead to failure of any overload situation which may not be covered under product warranty.

- Dimensions depending on Module type in (mm)

and base must be flush with the frame.

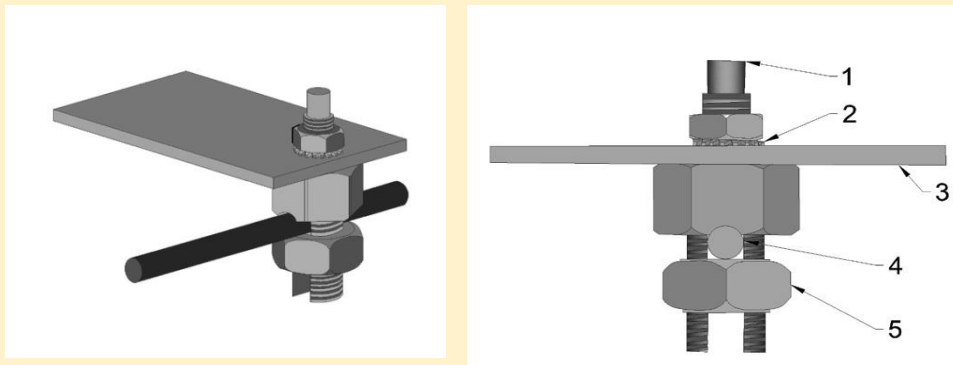
12.3 Module Grounding

- Appropriate grounding is done by bonding the module frames and all the metallic structure together with the help of a grounding conductor made of copper, copper alloy or other material as per the electrical conductor prospective of respective national standards. The grounding connector should be connected to earth with the help of earth ground electrode.
- In case of metallic support, the surface of the frame must be electroplated,
- First, carefully strip 16mm of the insulating jacket from the end of grounding wire to avoid nicking or cutting conductors, insert the wire into the slot of the lug (see picture), and screw down the slotted screw.
- To fulfil the grounding & bonding requirements, please refer to the regional and national safety and electrical standards. Always use recommended type of connectors or similar for grounding.
- If grounding is required, the grounding wire must be properly fastened to the module frame to ensure.
- Screw must be tightening with torque of 2.3 to 2.8 Nm [20 and 25 in. - lbs.]. The head of the screw must be flushed with the base



- Appropriate grounding is done by bonding the module frames and all the metallic structure together with the help of a grounding conductor made of copper, copper alloy or other material as per the electrical conductor perspective of National Electrical Codes. The grounding connector should be connected to earth with the help of earth ground electrode.
- For grounding hole location and its size please refer to the product catalogue.
- Pahal recommends following grounding procedures for the proper groundings.

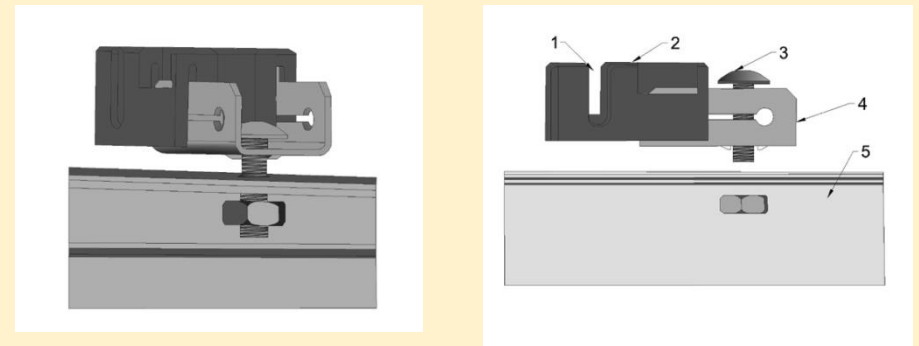
12.3.1 :- Grounding by bolts: 2058729-1



- 1) Wire bolt and slot 2) Mounting wash hex nut
3) Aluminium frame 4) 4 to 16mm² cable 5) HEX nut

- Tyco made grounding hardware comes with grounding bolt, mounting and grounding hex nut inside the package.
- Electrical contact developed by penetration of anodized coating of the aluminium frame and tightening the mounting.
- Grounding wire dimension should be considered of 6 to 12 AWG solid bar copper and installed under the wire binding bolt.
- Tightening of wire binding bolt must be done at proper torque level 45 in lb.

12.3.2 :- Grounding by bolts: # 2058729-1

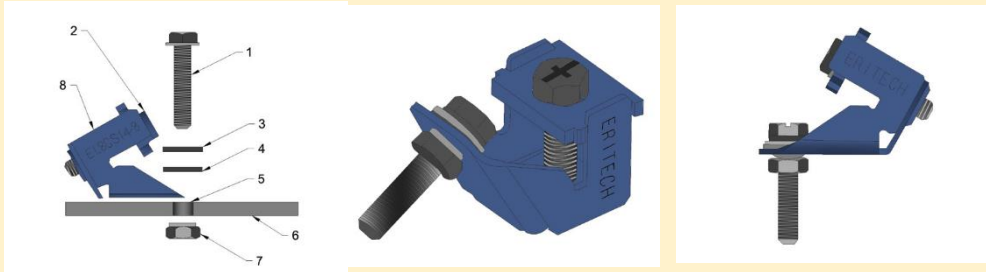


- Tyco made grounding hardware comes with grounding bolt, mounting and grounding hex nut inside the package.
- Electrical contact developed by penetration of anodized coating of the aluminium frame and tightening the mounting hex nut applying proper torque of 25 in lb. Hex nut comes with a star washer.
- Grounding wire dimension should be considered of 6 to 12 AWG solid bar copper and installed under the wire binding bolt.

- Tightening of wire binding bolt must be done at proper torque level 45 in lb.
- Tyco grounding bolt is only recommended to use with 6 to 12 AWG solid copper wire.

- Grounding bolt can be used with only 6-12 AWG bare copper wire.
- Machine bolt must be torqued up to 35 in lb for the proper wire binding.

12.3.3 : ERICO grounding bolt EL6CS14-6



- 1) Machine bolt A
- 2) Machine bolt B
- 3) Belleville washer
- 4) Flat washer
- 5) Clearance hole for 10[M5] machine bolt
- 6) Aluminium frame
- 7) Machine bolt hex nut with lock washer
- 8) Grounding bolt

It is recommended that lug should be installed on a surface that is larger than the bottom surface of the lug.

- Lug should be fixed on the grounding holes present on the PV module.
- To secure grounding bolt to the module frame machine bolt A should be torqued to 35 in lb,

12.4 MODULE WIRING

All wiring should be performed, by qualified installers. All wiring should be done in accordance with applicable electrical codes and regulations. Modules can be connected in series to increase the operating voltage by plugging the positive plug of one module into the negative socket of the next. Before connecting modules always ensure that the contacts are corrosion free, clean and dry.

Product can be irreparably damaged if an array string is connected in reverse polarity to another i.o. If the positive end is connected to negative input of the string combiner box and vice versa. So proper connection in the right polarity is recommended and if any reverse polarity is soon or any difference of more than 10 V is observed, the string configuration connection needs to be checked and connected appropriately.

PAHAL Solar modules are provided with standard Cables with a 4 mm * cross-sectional area and arc rated up-to 1500 V (IEC and UL) for maximum system voltage.90' C and are UV resistant. Ensure the cables are not exposed to water logged area's.

The maximum voltage of the system should be lesser than the certified system voltage (typically 1500 v) or the maximum input voltage of the inverter.

Actual Maximum system voltage & minimum string fuse rating of Installed system can be calculated as per below formula to identify the recommended maximum series/parallel module configurations.

Max System voltage = $X * V_{oc} * [1 - ((T_a - V_{oc} (\%) \times (25 - T_{min})))]$

Minimum string fuse rating = $I_{sc} \times 1.25 \times \text{Max} (1.175, I_m \div I_{ma})$

X – No of modules, which are connected in series

V_{oc} - Open circuit voltage of each module (Refer to the Data Sheet)

$T_a - V_{oc}$ - Thermal coefficient of Open circuit voltage for the module in Percentage

T_{min} - Minimum ambient temperature of the location of the plant

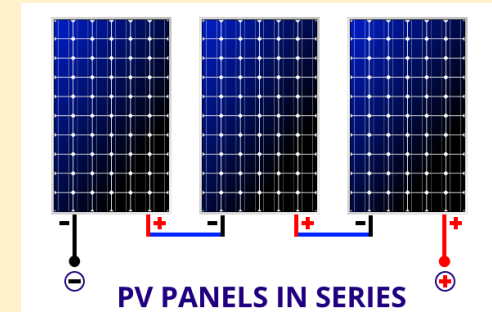
I_{sc} - Short circuit current of each module at 0% bifacial gain (in case of bifacial module)(Refer to the Data Sheet)

I_{ma} - The highest 3-hour current average resulting from the simulated local simultaneous irradiances on the front and rear sides of the PV array accounting for elevation and orientation

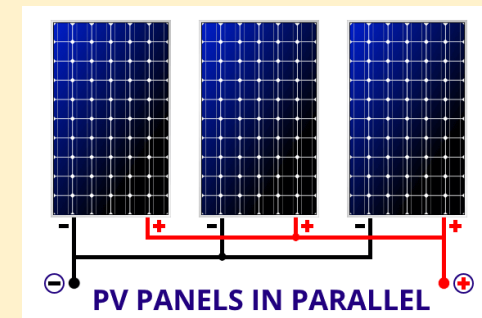
I_m - The MPP operating current at 0% bifacial gain (in case of bifacial module) (Refer to the Data Sheet)

Type of Wiring

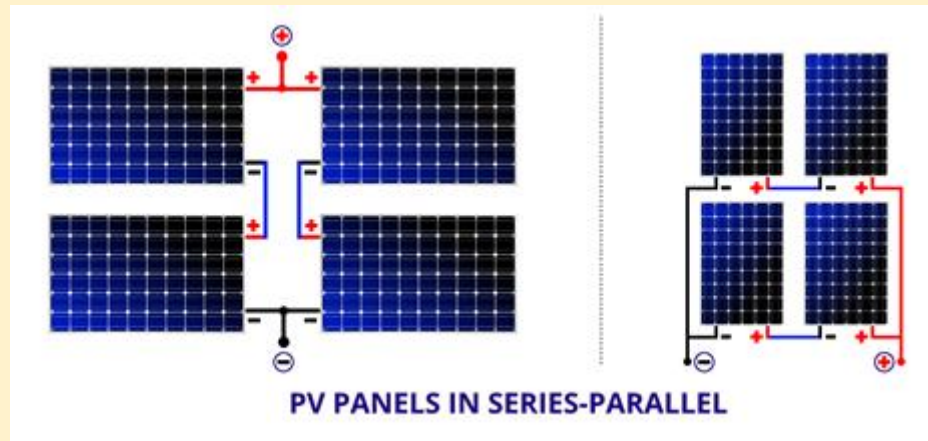
12.4.1 SERIES WIRING



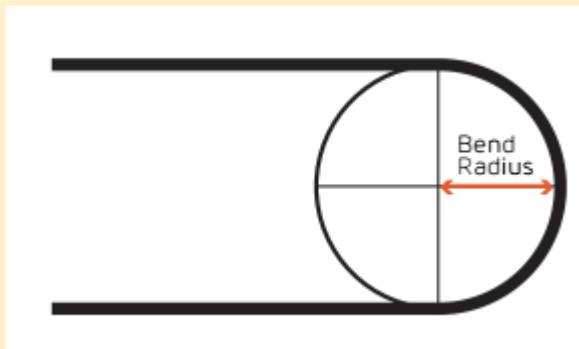
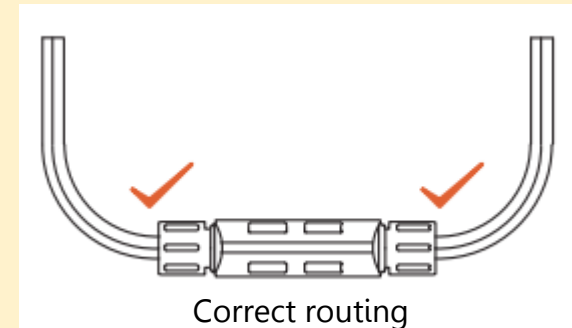
12.4.2 PARALLEL WIRING



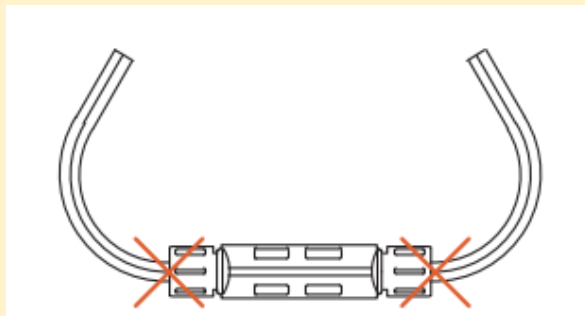
12.4.3 SERIES PARALLEL WIRING



Incorrect routing



Bending radius of junction box should be minimum 44 mm



12.6 BYPASS DIODES

- Diode replacement of potting type Junction is not possible in case of any type of failure. If any bypass diode stops working then the only way to correct the problem is to replace the complete Junction box with new one. To replace Junction Box PAHAL SOLAR recommends contacting the supplier.
- Bypass diodes divert current from the cell strings in the event of partial shading.

12.7 Cables and Wiring

- Use field wiring with suitable cross-sectional areas that are approved for use at the maximum short-circuit current of the PV module. Pahal recommends installers to use only sunlight resistant cables qualified for direct current (DC) wiring in PV systems. The minimum wire size should be 12 AWG. The temperature range of the cables is -40°C to $+90^{\circ}\text{C}$.
- The positive (+) terminal has a female connector while the negative (-) terminal has a male connector. The module wiring is intended for series connections (i.e. female (+) to male (-) interconnections).
- Cables should be fixed to the mounting structure in such a way that mechanical damage to the cable and/or the module is avoided. Maintain a minimum cable-bending radius greater or equal than five times the cable diameter. Route the cable in a way that the tensile stress on the conductor or connections is prevented. For fixing, use appropriate means, such as sunlight resistant cable ties and/or wire management clips specifically designed to attach to the PV module frame. While the cables are sunlight resistant and waterproof, where possible, avoid direct sunlight exposure and water immersion of the cables.

13. ELECTRICAL CONFIGURATION

- Photovoltaic (electric) systems operate automatically and require very little day-to-day supervision. The solar array generates DC electricity whenever light falls on it similarly the inverter automatically turns ON as soon as there is sufficient energy from the solar array to efficiently convert this into grid.

CAUTION

Solar modulo is rated to operate at potentially lethal DC voltages which have the potential can cause severe electrical shock, arcing and fire hazards. Whilst some solar modules, manufactured by PAHAL, are certified to operate up to 1500 V DC always check the module Back label to confirm the actual rating of your product before making connections.

- It is recommended to use a suitably rated isolator (DC switch) to interrupt the current flow before Disconnecting the connectors. Even after disconnecting, the DC power may be active for some time, hence only expert operators are recommended to operate upon the panels, string combiner box. etc. PAHAL SOLAR will not be responsible for any electrical accidents occurring in power plants using PAHAL SOLAR modules.

13.1 FUSE

- When fuses are fitted they should be rated for the maximum DC voltage and connected in each. Non-grounded pole of the array (i.e. if the system is not grounded then fuses should be connected in both the positive and negative poles). The maximum rating of a fuse connected in series with an array string can be found on the product label and in the product datasheet.
- This fuse rating value also corresponds to the maximum reverse current that a module can withstand (when one string is shaded then the other parallel strings of modules will be loaded by the shaded

string and current will flow) and therefore impacts the number of strings in parallel.

14. SELECTION OF INVERTER AND COMPATIBILITY

• Only connect the quantity of modules that corresponds to the voltage specifications of the inverters used in the system. When installed as per the IEC standards and regulations, Pahal Solar modules do not normally need to be electrically connected to earth and can operate with either galvanic ally isolated (with transformer) or transformer less inverters. If galvanic ally isolated inverters with transformers are used, the negative pole of the array must be connected to earth. If a transformer less inverter is used, the installer should ensure that the right active negative earthing / grounding or PID Controller kit is installed by consulting with the inverter supplier and taking approval from the inverter supplier. Both methods are required in order to prevent the modules from potential induced degradation in the field.

15. MAINTENANCE & CLEANING OF PV MODULE

- It is common for dust and dirt particles to accumulate on the surface(s) (front and back in case of bifacial modulo) of the Modulo. This can reduce the optimal output performance of the solar Modules. Normally, the accumulated dust can be washed with water, but in some instances some maintenance is recommended to clean the surface of the glass with water and a soft cloth or sponge to remove layer of dirt. A mild non-abrasive detergent may be applied to remove persistent dirt.
- It is advisable to perform periodic inspection of the Modules for damage to glass, backsheet. frame, junction box or external

electrical / loose connections and corrosion by the authorized professional.

- PV Modulo Cleaning should be done only by properly trained personnel who understand the risks of applying water to electrical components.
- No aggressive and abrasive cleansers or chemicals should ever be used on the coated front glass. No alkali- based chemicals should be used, including ammonia based solutions.
- Always wear rubber gloves for electrical insulation while maintaining, washing or cleaning Modules. Appropriate electrically insulating Personal Protective Equipment (PPE) must be worn during any cleaning or inspection operations.
- Always make sure that Cleaning should not be done during Generation time, the recommended time to clean Modules is from dusk to dawn when production is not affected and risk of electrical shock hazard is minimized. During the generation time the temperature of Module is higher and washing may also cause thermal stress in Module.
- Acceptable Module cleaning methods are to spray the Modules with low-pressure water closely matched in temperature to the Module or to use a dry cleaning technique. Do not apply water that is more than 20°C warmer or colder than Module surface temperature.
- Maintenance should be carried out at least once a year by trained personnel, always wearing safety gloves and safety shoes.
- Trim any vegetation which may shade the solar array thus impacting performance.
- Check that mounting hardware is properly tightened.

- Inspect all cables to verify that connections are tight; the cables are protected from direct sunlight and sited away from areas of water collection.
- Check that all string fuses in each non/earthed pole are operating.
- It is recommended to check the torque of terminal bolts and the general condition of wiring at least twice in a year. Also, check that mounting hardware is properly torqued. Loose connections will result in damage to the array.
- Replacement modules must be of same type. Do not touch live parts of cables and connectors, use appropriate safety equipment (insulated tools, insulating gloves ,etc.) when handling modules.
- High pollution or close to large bird populations will require more regular cleaning.
- The back surface of the mono-facial module normally does not need to be cleaned but if needed, avoid the use of any sharp projects that might penetrate the substrate material.
- The amount of electricity generated by a solar module is proportional to the amount of light falling on it a module with shaded cells will produce less energy and therefore it is important to keep modules clean.
- For cleaning of Modules Fresh water (TDS < 1500 mg/l) may be used. If needed, a mild, non-abrasive, non- caustic detergent with a final fresh water and detergent solution mix between 6.5 < pH< 8.5 at 25°C may be used.
- Do not clean or spray water at the Junction Box.
- Frequency of Cleaning will vary depending upon any special conditions in the area where the Modules are installed. Modules installed in high windy or dusty area should be inspected more frequently.
- For More Details. Refer to our cleaning guidelines.