

INSTALLATION MANUAL

FRAMED SOLAR PV MODULES

WAAREE[®]
SOLAR AMERICAS INC



INSTALLATION AND OPERATION MANUAL

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1. INTRODUCTION

This manual contains information regarding safe handling, installation, operation and maintenance of WAAREE Photo Voltaic (PV) Modules. Before installation or using the PV Modules, it is important to read this manual and understand the instructions carefully.

2. DISCLAIMER OF LIABILITY

Since Installation and Maintenance of the Module are beyond (WAAREE) company's control; WAAREE does not assume responsibility and disclaims liability for loss, damage, injury or expense arising out of or in any way connected with such installation, operation, use or maintenance of the Modules.

WAAREE assumes no responsibility for any infringement of patents or other rights of third parties that may result from use of the Module. No license is granted by implication or otherwise under any patent or patent rights.

The information in this Manual is based on our knowledge and experience and is believed to be reliable; but such information including product specifications (without limitations) and suggestions do not constitute a warranty, expressed or implied. WAAREE reserves the right to make changes to the product, specifications or this manual without prior notice.





3. GENERAL INFORMATION

The installation of solar PV Modules requires great degree of skills, it should only be performed by a qualified and licensed professional, including, without limitation, licensed contractors and licensed electricians. The installer assumes the risk of all injury that might occur during installation, including without limitation, the risk of electric shock.



Warning

For your safety and the safety of others, please read the entire Installation, operation and maintenance manual carefully prior to installing, wiring, operating and performing maintenance of PV modules. Also, carefully read the Module Data Sheet provided with this product. Determine local permits, installation and inspection requirements before installing module(s). If not otherwise specified, it is recommended that the requirements of the regional & National Electric Code (NEC) be followed.

The photovoltaic Module produces electricity when exposed to the sunlight, even at low light levels or when other sources illuminate the front face. The voltage of a single Module is less than 50 V DC and around or over 50V DC for bifacial module. However, the voltage increases as Modules are connected in series and the available current increases as the Modules are connected in parallel. Thus, for a Module connected within a system, contact with electrically active parts of the Module such as terminals can result in lethal shock, sparks and burns. The only way to eliminate this hazard is to prevent exposure of the Module(s) to light.



Caution

To avoid the hazard of electric shock and injury when installing, wiring, operating and maintaining the PV modules, below guidelines shall be strictly followed

4. SAFETY PRECAUTION

- » Potentially lethal DC voltages can be generated whenever PV Modules are exposed to a light source, therefore, avoid contact with electrically active parts and be sure to isolate live circuits before attempting to make or break any connections.
- » Only authorized and trained personnel should have access or perform work on the modules or solar system, always wearing safety gloves and safety shoes.
- » When working on electrical connections, remove all metallic jewelry, use properly insulated tools and wear appropriate personal protective equipment to reduce the risk of electric shock.
- » Since sparks may occur, do not install the Module where flammable gases or vapors are present.
- » 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 I_{sc} and V_{oc} marked on this module should be multiplied by a factor of 1.25 when determining component voltage ratings, conductor current ratings, fuse sizes and size of controls connected to the PV output
- » For modules under UL investigation, most of the time, the solar module is likely to produce more power, or current, than that rated at standard test conditions. Accordingly, the value of I_{sc} marked on back label of module should be multiplied by a factor of 1.25 when determining the conductor current ratings, fuse sizes and size of controls connected to the PV output. Refer to Section 690.8 of the National Electric Code to check when an additional multiplying factor of 1.25 may be applicable.





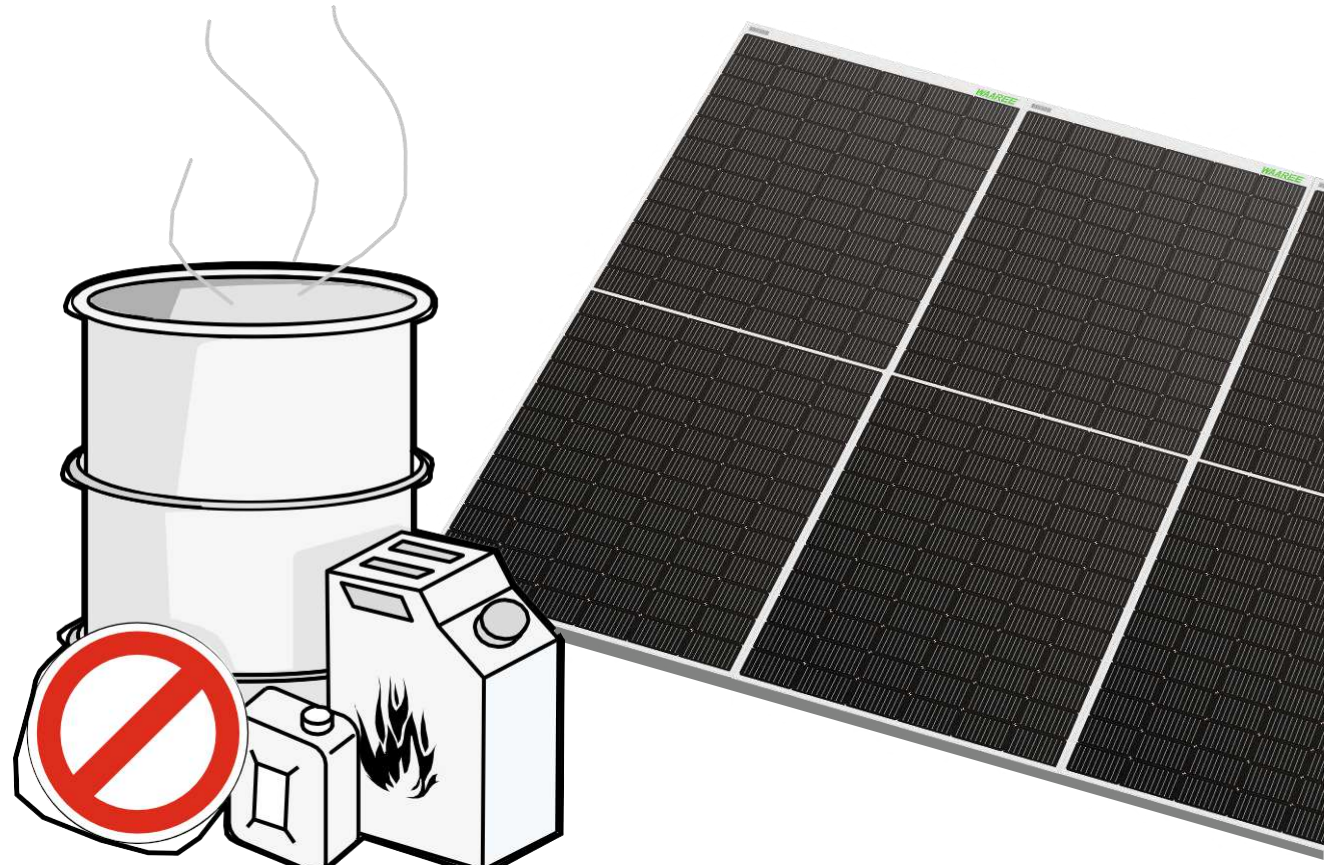
- » Where common grounding hardware (nuts, bolts, star washers, spilt-ring lock washers, flat washers and etc.) is used to attach a listed grounding/bonding device, the attachment must be made in conformance with the grounding device manufacturer's instructions.
- » Rated electrical characteristics are within the production tolerance of measured values at Standard Test Conditions of 1000 W/m², 25 °C cell temperature and AM 1.5 solar spectral irradiance, according to IEC 60904-3.
- » The module is considered to be in compliance with UL1703/UL 61730 only when the module is mounted in the manner specified by the mounting instructions.
- » Broken modules cannot be repaired and contact with any module surface or frame can lead to electrical shock. Do NOT use a module with broken glass or torn substrate.
- » Do NOT disassemble the modules or remove any part of the module.
- » Protect the electrical plug contacts against corrosion and soiling. Make sure that all connectors are corrosion free and clean before making the connection.
- » Do NOT install or handle modules when they are wet or during periods of high wind.
- » Make sure that the polarity of each module or a string is not reversed considering the rest of the modules or strings. The similar witness of polarity shall be checked at the combiner box/ array junction box/ inverter and/or at appropriate level.
- » Use Module for its intended function only.
- » Be sure that all other system components are compatible, and they do not subject the Module to mechanical or electrical hazards.

- » Do not touch terminals while Module is exposed to light or during installation. As a precaution use properly insulated tools only.
- » Do not damage or scratch the back sheet of the Module. Do not expose Back sheet directly to sunlight.
- » Do not drop Module or allow objects to fall on the Module. Do not stand or step on the Module.
- » Do not disassemble, modify or adapt the Module or remove any part or labeling installed/ pasted by the manufacturer.
- » When carrying a Module, two or more people should carry it by its frame wearing non-slip gloves (to avoid injury by a slipped Module, or by the edge of frame, and so on).
- » Only PV Modules with the same cell type, same power output and size should be connected.
- » Avoid uneven shade on the PV Module surface. Shaded cells may become hot (hot spot phenomenon) which may result in permanent damage to the Module.
- » Do not drill holes in the frame or glass of the Module, it may compromise the frame strength and cause corrosion of the frame and also voids the warranty.
- » Do not treat back sheet and front surface of the Module with paint and adhesives, Such cases will void Warranty.
- » Artificially concentrated sunlight shall not be directed onto the front or back face of the PV module.
- » Be sure to completely ground all Modules.
- » Do not use the junction box to hold or transport the Module
- » The maximum open circuit voltage of an array must not be greater than the specified maximum system voltage. Voltage is directly proportional to the number of PV Modules in series and is affected by weather conditions.



4.1 FIRE SAFETY

- » In the case of a fire, SPV modules may produce dangerous voltage/surge current, even if they have been disconnected from the inverter, or have been partly or entirely destroyed, or the naked wiring destroyed. In the event of fire, inform the fire/safety team about the particular hazards from the PV system, and stay away from all elements of the PV system during and after a fire until the necessary steps have been taken to mitigate the risk.
- » Before mounting the module, please consult your local building department to determine approved roofing materials.
- » Any module or panel mounting system has limitations on specific inclination required to maintain a specific System Fire Class C Rating.
- » The fire rating of the module is valid only when mounted in the manner specified in the mechanical mounting instructions.
- » A minimum slope of 5 in/ft. for installation over a roof is required to maintain the fire class C rating. Refer to your local authority for guidelines and requirements for building or structural fire safety. For roof application, the Modules should be mounted over a fire resistant covering rated for the application.
- » Ensure that all connections are securely made with no gap between the contacts. Any gap can result in electrical arcing that can cause a fire hazard and/or an electric shock.
- » Do NOT use water to extinguish fires of an electrical origin



5. STORAGE, UNPACKING & HANDLING OF PV MODULE

This manual provides guidelines for safe handling of WAAREE PV Modules during transportation, unpacking and storage. Improper handling may result in module damage, which can have an impact on both module performance and safety. The manual uses the term "module" or "PV module" to refer to one or more WAAREE Solar PV modules. The manual applies to all types of vertical landscape package (short-side vertically placed) solar PV modules, including both mono-facial and bifacial PV modules.

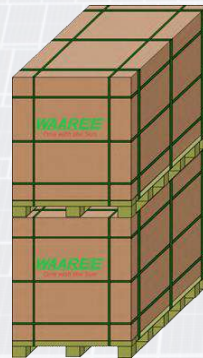
5.1 PRECAUTIONS FOR FORKLIFT HANDLING

- » Only authorized person shall operate forklift.
- » In the process of Loading and Unloading, selection of the appropriate forklift is mandatory with respect to pallet dimension and weight of the pallet. (Thumb Rule: Forklift capacity should be double the pallet weight).
- » The spacing of the forks should be adjusted with respect to the pallet dimension and weight ensuring the load is equally distributed on the overall forks.
- » If the fork length is less than $\frac{3}{4}$ of the size of the pallet, extensive sleeves should be fitted over the forks, before performing the activity.
- » For unloading the goods from the length side of the module, a higher capacity and long length forks to be used to ensure less vibration and steady unloading of the modules.
- » Sharp objects (Forklift fork corners) contact with the module box or pallet collision should be avoided, so as not to damage the internal PV modules.
- » Atleast one engineer must be present during the loading and unloading activity ensuring the appropriate commands are directed to the forklift driver.
- » Ensure smooth lifting and shifting of the PV modules inside the container to avoid vibrations and turbulence during the transportation.

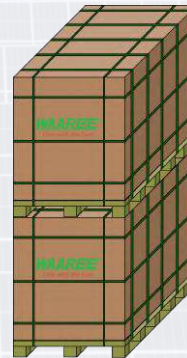


5.2 UNLOADING OF PV MODULES WITH A FORKLIFT

- » WAAREE uses industry best practices to load PV modules in shipping containers for the transportation.
- » Do not allow use of poor or damaged equipment for unloading of the PV modules.
- » Maintain safe distance during operation of forklift to ensure the safety of individuals in the vicinity.
- » When unloading the modules, it is important to select a forklift that has the appropriate tonnage based on the weight of the modules. When unloading, it is important to ensure that the forks are inserted into the pallet at a depth of at least 75% of the pallet's length.
- » The 3-D images of the vertical landscape package and vertical portrait packages are shown below. However WAAREE follows vertical landscape packaging for the domestic and export packaging.



2-Stack Vertical landscape package
(Export Packaging, short-side vertically placed)



2-Stack Vertical landscape package
(Domestic Packaging, short-side vertically placed)



1-Stack Vertical portrait package
(long-side vertically placed)

- » In any case, solar vertical landscape packages shall not be stacked more than two layers.



- » For safety reasons, it is recommended to drive the forklift in reverse when the sight is blocked by the packing box. Additionally, it is important to have proper supervision and clear instructions to avoid any accidents or damage to modules or personnel.
- » The PV module pallets should be placed at dry, flat and solid surface in the warehouse and at the installation site.



5.3 UNLOADING ACTIVITY USING HOIST CRANE

- » Appropriate section of the hoist crane vehicle is mandatory and the equipment shall be ensured by the professional which are fit for the activity.
- » Depending on the weight and capacity of the PV module pallet, the sling strip material selection should be appropriate and should have the carrying capacity of the module pallet.
- » Before lifting, the weight distribution over the slings should be evenly distributed on both the sides to avoid the case body tilting to one side during lifting.
- » Before lifting, the box should be kept balance to avoid module tilting.
- » Necessary fixtures are to be ensured while lifting the modules with slings to avoid the sling marks and damages to the box and PV Modules.

5.4 INSTRUCTIONS FOR HANDLING PV MODULES

- » Professional installers must read these guidelines carefully and strictly follow these instructions. Failure to follow these instructions may result in death, injury or property damage.
- » The installation and handling of PV modules require professional skills and should only be performed by qualified professionals. Installers must inform end-users (consumers) of the aforesaid information accordingly.
- » Loading of the PV modules shall be done using a flat surface, tilted or uneven ground might affect the module safety.
- » The height of the unloading platform and the height of the unloading ramp structure should be kept at a nominal level with the bottom of the container/open-trailer, whereas the recommended height tolerance should be controlled within $\pm 10\text{mm}$.

- » The total length of the unloading ramp should be the sum of the width of the forklift and the length of the goods, from the container/open-trailer distance for smooth backward movement.



- » When unloading of the PV modules on the platform or ground appropriate tools should be used for assisting in moving the goods out of the container smoothly, to avoid bumps caused by the gap between container/open-trailer and the platform.
- » The inclination angle between the fixture and pad should not be more than 5°, so as to avoid the forklift collision (with Module Pallet) to the top of the container when it comes out of the container.
- » When unloading cross-loading modules, special commands to be directed to the forklift driver to ensure forklift does not exceed the modules and prevent damage to adjacent modules when forks are raised or placed due to excessive length of forklift arms.



- » The forklift arms should be equi-spaced with respect to the pallet dimension in horizontal direction ensuring the load is equally distributed over the forks and should pull out the modules slowly and smoothly.



- » During the Fork-out activity of the PV modules, a distance of 2-3 cm should be kept between module and the box walls and then push back slowly to prevent the box from being damaged by the modules or adjacent pallets.



- » When the goods move out of the container port, please lower the fork height and slow down, please ensure the bottom height and the top height of the container to avoid collision and the whole pallet is moved out slowly from the container.

- » Sufficient space between two pallets recommended for ensuring safety concerns and avoiding the Pallet / Module Scratching during second pallet movement.



5.5 GENERAL INSTRUCTIONS AND SAFETY PRECAUTIONS

- » Follow WAAREE Company's unpacking procedure to unpack the PV modules.
- » Firstly upon arrival, ensure that packaging box is in good condition.
- » Do not allow unprofessional workers for performing the handling and unloading activity at site or warehouse.
- » If pallets are required to be stored onsite, we recommend the pallet packaging must be kept intact so as to protect the panels inside from direct exposure to the environmental conditions. The pallets can be stored in outside environment with no further requirement of extra shielding or tarping.
- » Do NOT stack more than the maximum amount of allowable pallets on top of each other.
- » The handling of modules requires great diligence. Therefore, caution is required while unpacking, transporting and temporarily storing these Modules.
- » Carefully read the unpacking instructions provided by the manufacturer (supplier). It is important to verify the product type, serial number and other information provided with the packaging box.

- » Use knife/cutter for carefully removing packaging strip and wrap.
- » Verify the barcodes and details of the modules with information provided in the packaging box.
- » Use insulating gloves when handling the modules.
- » Do NOT place modules directly on top of each other without corner protect. Do not carry the Module on Head.
- » Always carrying a Module with the help of two or more people by its frame and wear non-slip gloves (to avoid injury by a slipping Module, cuts by the edge of a frame etc.). Do not leave the Module unsupported or unsecured prior to installation.
- » After unpacking if all the modules are not utilized, the remaining modules shall place horizontally with aligned frame on the flat-solid surface and repackaged. Horizontal stack of the modules shall not contain more than 16 modules per stack.
- » Do not place Modules on an uneven surface, for example, wind can cause a Module which is leaning against a fence to fall and break.
- » Avoid applications of excessive bending or twisting of the Module, it may cause severe micro-cracks at the cell level, which in turn may compromise Module reliability.
- » Avoid handling and lifting modules with the junction box and cables.
- » At the installation site, take care to keep Modules and particularly their electrical contacts clean.
- » A Module with broken glass or torn backsheet cannot be repaired and must not be used since contact with any Module surface or the frame can produce electrical shock.
- » Take proper anti-tilting measures while removing the inner packaging strip.
- » Broken or damaged Modules must be handled carefully and disposed off properly. Broken glass can be sharp and may cause injury if not handled with appropriate protective equipment.
- » Do not stand, step, walk and/or jump on the Module. Do not drop or place objects on the Modules (such as tools.)
- » Do not mark the Modules with sharp instrument. Particularly attention should be taken to avoid Module backsheet to come in contact with sharp objects, as scratches may directly affect product safety and reliability.

5.6 UNPACKING OF PV MODULES FOR THE INSTALLATION

- » Cut off the outer strapping strip and remove plastic wrap across the pallet using pliers/cutter.



- » Open the box from top and cut off top inner strapping strip.



- » Lift the outer box and cut off bottom inner strapping strip.



- » Again put the cover down and peel of the retainer strip from one module.



- » Peel of the retainer strip one by one module.



- » Sequentially remove the PV modules from the package and handle package carefully to prevent tilting/falling by side.



- » Place the PV modules next to the solid or self-standing structure to prevent from falling.
- » Inspect the modules for damage on the frame or glass. In case of damage, report to the authorized person.
- » Before starting the installation process, follow WAAREE Energies Limited's Installation Manual for PV Modules.
- » Always lift module with the help of two people from module short edge.



- » Avoid drilling holes in the module's frame. Doing so will void the product warranty, compromise frame's loading capacity and may result in frame corrosion.

Don'ts :

- » Don't alter the integrity of the frame of PV module.
- » Don't unpack modules on the wet, soft or inclined surface.
- » Don't use sharp or unstable structures for support.
- » Don't walk, stand or jump on the PV module.
- » Don't remove the packaging and strips if not installing immediately.
- » Don't stack over number of PV modules.
- » Don't hit the module with sharp or heavy objects.

Please keep this manual for future reference. We recommend visiting www.waaree.com regularly for the most updated version of this manual.

For any further information and clarification, please contact WAAREE Energies Limited

6. ENVIRONMENTAL CONSIDERATION AND SITE SELECTION

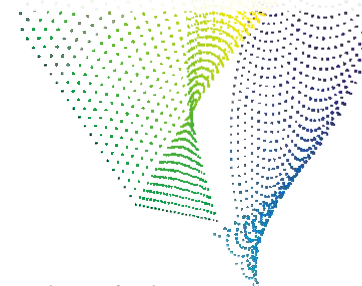
WAAREE Solar modules are certified for IEC 61215, IEC 61730-I & II, IEC 62804. In addition to the required IEC certification to meet European standards, WAAREE Solar products have also been tested and certified for resistance to ammonia fumes (IEC 62716) that may be present in barns sheltering cattle, pigs, as well as sustainability for Installation in Humid (coastal) areas of high sand storms. Although WAAREE PV modules have passed Salt mist (IEC 61701) corrosion test 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.

* NOTE :

- The mechanical load bearing capacity depends upon the Installer's mounting methods and failure to follow the instructions of this manual may result in different capabilities to withstand snow and wind loads. The system installer should ensure that installation methods used meet these requirements and any local codes and regulations.
- Rated electrical characteristics are within the production tolerance of measured values at Standard Test Conditions of 1000 W/m², 25 °C cell temperature and AM 1.5 solar spectral irradiance, according to IEC 60904-3.

Environmental Conditions:

- Ambient temperature: -40 °C to +50 °C
- Operating temperature: -40 °C to +85 °C
- The relative humidity shall be below 85 %.
- Statement: the maximum altitude is up to 2000m



6.1 SITE SELECTION

- » PV modules should be installed in a place where there is no shading across the location throughout the year. Shading can be minimized by having the distance between the obstruction and solar array is more than thrice the height of obstruction.
- » Solar module is recommended to be installed at an optimized tilt angle to maximize the energy output. It is roughly equal to the latitude of the project site as a rule of thumb, facing to equator. But always design the plant based on local situations to find out the optimum conditions.
- » PV modules should typically face south in the northern hemisphere and north in southern hemisphere. WAAREE modules can be mounted either in landscape or portrait orientation however the impact of dirt shading the solar cells can be minimized by orienting the product in portrait.
- » Modules shall be mounted with the orientation and tilt angle required for consistent performance (seasonally, yearly). The location selected shall have direct access to sunlight from 9:00A.M. to 3:00P.M. on the shortest day of the year.
- » A minimum slope of 5 in/ft. for installation over a roof is required to maintain the fire class C rating. Refer to your local authority for guidelines and requirements for building or structural fire safety. For roof application, the Modules should be mounted over a fire resistant covering rated for the application.

6.2 MODULE SPECIFICATION

- » Please refer to the latest Module datasheet for more details.

7. MOUNTING INSTRUCTIONS

- » 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.
- » When installing solar modules on a roof always leave a safe working area between the edge of the roof and the external edge of the solar array.
- » 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
- » Avoid using a mounting method that will block the drainage holes in the module frame. The drain holes cannot be blocked in any situation during installation or use.
- » 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.
- » Site-specific loads such as wind and snow need to be taken into consideration to ensure that the pressure of such a load does not exceed the specified maximum load.
- » Always abide by the instructions and safety precautions included with the Module. 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 snowfall. 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.



7.1 MECHANICAL MOUNTING METHODS

A. MOUNTING WITH BOLTS

Modules must be mounted on mounting holes located at rear side with the Appropriate stainless steel nut, bolt and washer. It is recommended to use stainless steel fixing only. Module mounting must use the pre-drilled mounting holes in the frame. Always select the length of mounting screw after considering a clearance of 5-10 mm between the Module back face & screw face to avoid any breakage of Module while tightening.

Applied torque should refer to mechanical design standard according to the bolt customer is using. For Mounting hole size of 8 x12mm – M6 bolt shall be use. For mounting hole size of 9 x 14 mm – M8 bolts shall be used.

The recommended tightening torque for M6 bolts and nuts is 12 Nm (8.85 ft-lbs) and for M8 bolts and nuts is 15-20 Nm (11.06-14.75 ft-lbs).

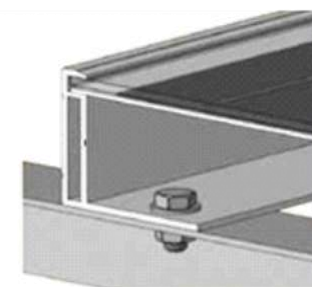
Please ensure that corrosion resistant materials are used for clamps, bolts and other hardware.

Note: -

Do not drill additional mounting holes on the frame & glass surface of the Module. Doing so will void the warranty.



1. Aluminium Frame
2. Appropriate Stainless Steel bolts
3. Flat Stainless Steel washer
4. Spring Stainless Steel washer
5. HEX Stainless Nut



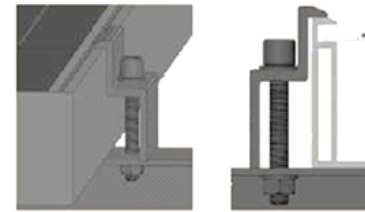
B. MOUNTING WITH CLAMPS

Each Module must be securely fixed to the mounting structure at a minimum of four points. The Module clamps shall not come into contact with the front glass and must not deform the frame. Be sure to avoid shadowing effects from the Module clamps. The clamp must overlap the module frame by at least 7mm (0.28in) but no more than 10mm (0.39in). The Module frame is not to be modified under any circumstances. When choosing this type of clamp-mounting method, use at least four clamps on each module, two clamps should be attached on each long sides of the module (for portrait orientation) or each short sides of the module (for landscape orientation). Depending on local wind and snow loads, additional clamps may be required to ensure that modules can bear the load. The applied torque shall be big enough to fix it steadily. For safety, it is better to follow the clamp manufacturer's recommendations.

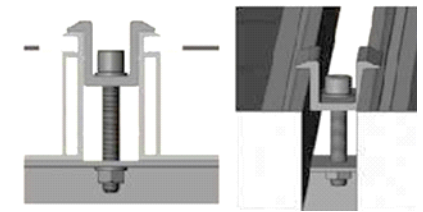
Tighten end and mid clamps with a standard drill or torque wrench (later preferable) The clamp material should be stainless steel or anodized aluminium alloy.

Note: Failure to comply the recommended installation method will void Waaree's warranty.

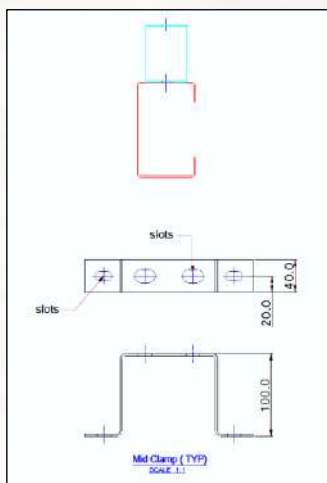
End Clamp installation



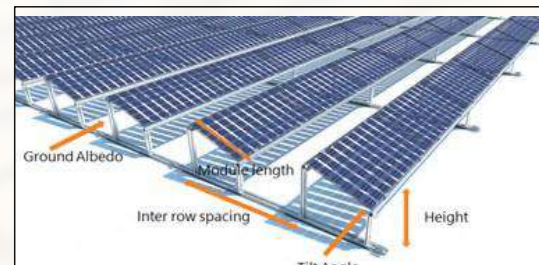
Middle Clamp installation



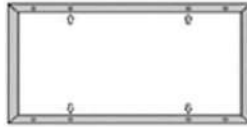
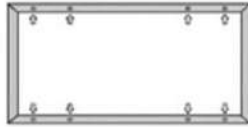
Guidelines for Bifacial modules installation:



1. Regular 2P arrangement may be considered, with additional clamp of (approximately 100mm) over and above the purlin to provide additional shadow free space for bi-facial module installation. Typical clamp detail is given in figure to the left.
2. Landscape arrangement can be used with purlin between the modules spaces/frame.
3. Minimum distance to be kept between the MMS purlin and rear side of the bifacial module to avoid any hotspot generation. The rear side shading loss permissible is upto 5%. Waaree recommends to increase the steel section of MMS to bare the additional load bearing capacity.



C. INSTALLATION DIAGRAM

	2400Pa (1600Pa with design safety factors $\gamma_m=1.5$ load condition)	5400Pa (3600Pa with design safety factors $\gamma_m=1.5$ load condition)
	Low/normal level of load condition (applies to most of the environmental conditions)	High level of load condition (applies to harsher environmental conditions such as storm, heavy snow, etc)
Mounting system	◦ Mounting holes  Use four mounting holes	◦ Mounting holes  Use eight mounting holes

Different mounting configurations can be tried as per Installer's calculations; 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 WAAREE's warranty.

Before design mounting structure needs to be considered design safety factors $\gamma_m=1.5$, positive 3600 Pa and negative 1600 Pa to avoid site failure.

Please note that in areas with heavy wind speeds or snowfall, further counter measures may be required such as use of additional clamps, longer clamps or additional support bar to avoid module damage.

PV system EPC team (Designer and Installer) will be responsible for correct calculation of loads and to ensure module supporting structure meets all applicable requirements. WEL's warranty will void in cases where improper clamps or installation methods are found.

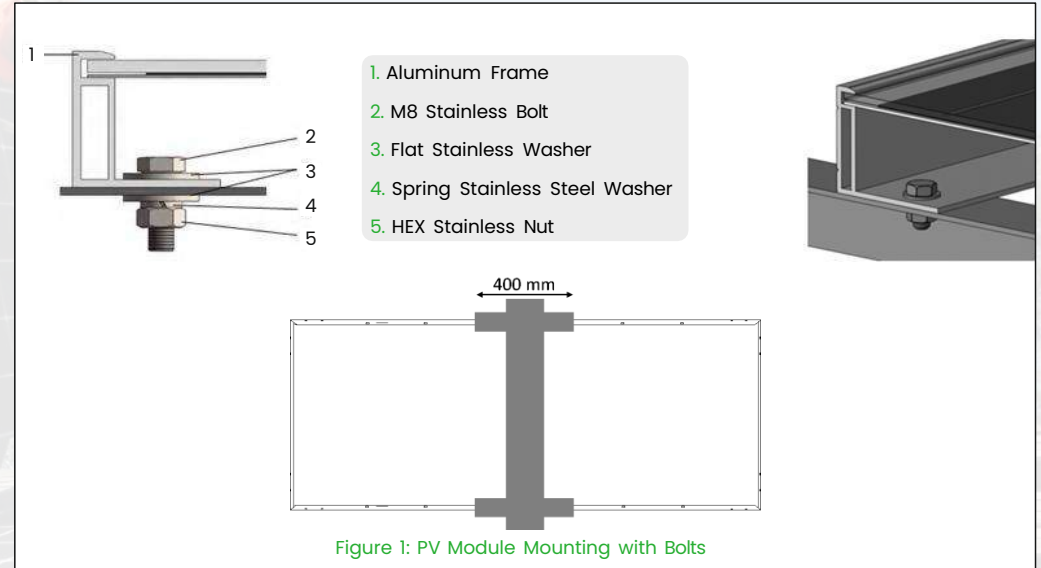
D. MOUNTING GUIDELINES FOR PV MODULES WITH TRACKER SYSTEM

- » Prior to installation, it is important to address the following items: (i) carefully inspect the module for any signs of damage. Ensure the module is thoroughly cleaned to remove any dirt or residue that may have accumulated during shipping. (ii) verify the serial numbers of the received PV modules.
- » The mounting structure should be constructed using durable materials that are resistant to corrosion and UV radiation.
- » In areas that experience significant winter snowfall, it is important to modify the height of the mounting system to ensure that the lower edge of the module remains free from snow accumulation. Furthermore, it is important to make sure that the lower part of the module is not obstructed by vegetation, trees or susceptible to damage from flying sand or stone.
- » Ensure that the backsheet/glass of the modules remains free from contact with any brackets or mounting structures that could potentially puncture/break the modules.
- » If there is a possibility of high pressure load due to local wind and snow conditions, it may be necessary to provide additional support in form of longer clamps or rails or bumpers to ensure that the module can withstand the high wind loading.
- » Do not drill additional mounting holes on the frame & glass surface of the module. Doing so will void the warranty.



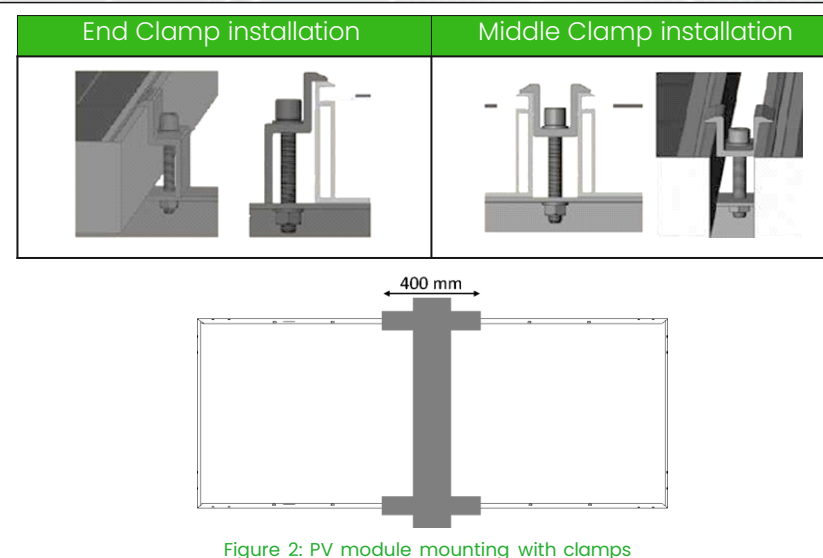
MOUNTING WITH BOLTS

WAAREE modules are equipped with 4 mounting holes (14 mm (L) * 9 mm (W)) that are compatible with M8 bolts. Additionally, there are 8 mounting holes that are compatible with M6 bolts, are 400mm in size and are used for connecting with tracking systems. Secure the modules onto the bracket by fastening bolts through the mounting holes on the back-side frame as shown in the Fig. 1. The recommended tightening torque for M6 bolts and nuts is 8-12 N.m and for M8 bolts and nuts is 12-16 N.m. Please ensure that corrosion resistant materials are used for clamps, bolts and other hardware.



MOUNTING WITH CLAMPS

The module clamps should not touch the front glass and do not cause any deformation to the frame. Make sure to prevent any shadowing effects caused by the module clamps. When selecting this particular clamp-mounting method, it is important to ensure that a minimum of four clamps are used on each module. Two clamps should be securely attached to each of the longer sides of the module. If there is a possibility of high pressure load due to local wind and snow conditions, it may be necessary to use extra clamps or support to ensure that the module can withstand the load. Ensure that the applied torque value is sufficient to securely fasten the modules in place. It is recommended to follow the guidelines provided by the supplier of the clamp for the mounting of PV modules for the tracking system.

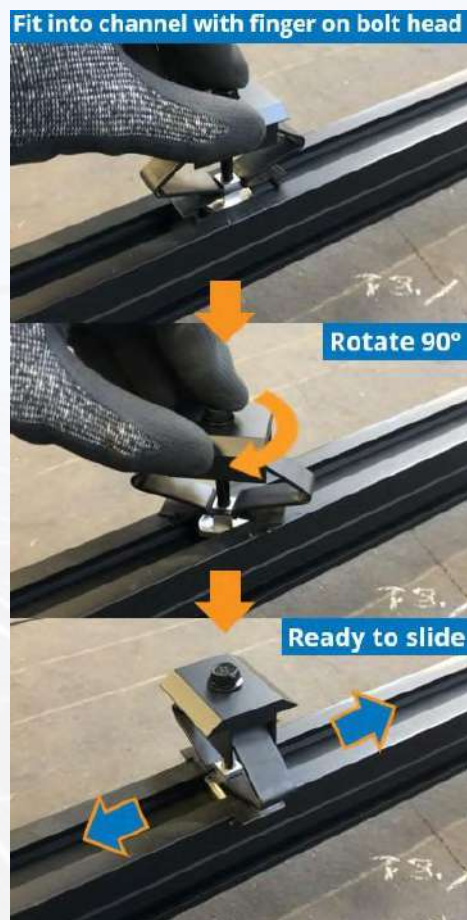


E. Universal InvisiMount Clamping (Mounting with Universal End Clamps & Universal Mid Clamps)

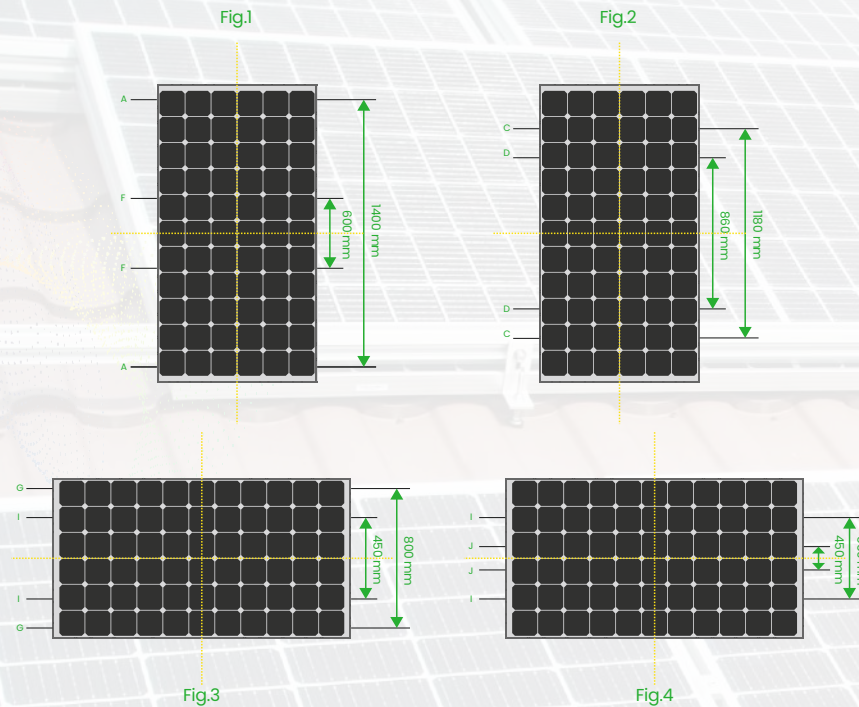
- » Position the first module of the row atop and at the end of the rails, and then tilt the module as necessary to connect the module j-box leads to the MI you attached to the rail previously
- » Position the module back on the rails and then lightly lift the module edge that's nearest the rail ends.
- » For each rail end: fit the upper silver piece of an end clamp into the top channel of the rail (Refer Fig.) and slide it in while fitting the tabs on the lower black piece of the end clamp into the main channel and then sliding the assembly in. Press on the bolt head to slide the clamp in as far as possible (Refer Fig.) .
- » Lower the module back down.
- » Verify correct module position and that the module is flush with the edge of the rail, then tighten each end clamp bolt to 85 +5/-0 in-lb (9.6 N-m) with a 10 mm socket. The clamp will compress and secure the module frame (Refer Fig.) .
- » Tug upward on the module to ensure the clamp is engaged and securing the module.
- » On the opposite side of the module, fit one mid clamp down into the top channel of each of the row's two rails, rotate it 90° (Refer Fig.) , and slide it back toward the first module. Leave the mid clamps loose for now.
- » Position the second module next to the first, connect its j-box leads to the MI you attached to the rail previously, and then lower the module back down on the rails.
- » For each of the two mid clamps, slide each clamp to engage one side of it fully against the first module frame; and then slide the second module toward the first, fully engaging its frame with the other side of the mid clamp (Refer Fig., second module not shown; and Refer Fig.).



- » Repeat the previous steps until you have installed all except for the last module in the row.
- » Tighten each of the two mid clamps $85 \pm 5/-0$ in-lb (9.6 N-m). Each module frame must be fully engaged with the sides of each mid clamp to ensure full contact with the bonding washer and continuity of the module-rail ground path.
- » For the last module in the row, position it on the rails in the desired location, then mark a cut line on each of the rails at the module edge.
- » Remove the module to ensure it is not damaged in the cutting process, then carefully cut the rails along the lines you marked. The maximum distance the module is permitted to overhang the rail is $1/4"$ (0.6 cm).
- » Place the module in position again, connect its j-box leads to the MI on the rail, lower the module onto the rails, and add its two mid clamps (which also secure the second-to-last module in the row). Tighten the mid clamps.
- » Add and tighten the last module's two end clamps.



F. APPENDIX



Various Module mounting position in Portrait and Landscape configuration with maximum allowed testing loads

Module orientation	Figure	Rail Mounting Range (mm)	Test Load (Pa)
Portrait	Fig.1	A-F=1400-600	+3000/-2800
Portrait	Fig.2	C-D= 860-1180	+6000/-3600
Landscape	Fig.3	G-J = 800-450	+3000/-2000
Landscape	Fig.4	I-J = 550-450	+4500/-2000

Note: The above mentioned Test load in Pascal are the maximum test loads upward and downward considering EL, visual and electrical performance meeting the IEC 61215 & IEC 61730 requirements.
Consider Test Load = Safety Factor * Design Load
Safety Factor = 1.5



G. Guidelines to be followed while dealing with AC modules:

Introduction, Construction and Functioning of AC Modules



Figure: Waaree AC module along with components description

AC Module- List of Components and Functioning:

1. DC Module: Will convert incident solar irradiation to DC power.
2. Junction box: DC module output terminals will connect to JB. From JB, DC cables will connect to MI input terminals.
3. DC Cable with Male and Female Connector: For connection with microinverter input terminals.
4. Micro-inverter: Will convert DC power generated by PV module to AC power.
5. AC module frame: Structural system to protect and support AC module.
6. AC Cable with Male Connector: From MI output socket, AC cable male connector will connect with an AC cable female connector or female end cap.
7. AC Cable with Female Connector: From MI output socket, AC cable female connector will connect with an AC cable male connector or male end cap.
8. Product Label indicates product specifications.
9. Model number: Consists of model number for AC module

List of Accessories:

1. Extension Cable (serviceable as a transition cable) has both female/male connectors paired with male/female end cap.
2. Male Connector can be used for connection with a female connector or a female end cap.
3. Female Connector can be used for connection with a male connector or a male end cap.
4. Female End Cap is for sealing male connector.
5. Male End Cap is for sealing female connector.
6. Unlocking Tool for handling male and female connectors.



Waaree AC module consists of regular DC module along with attached micro-inverter i.e. micro-inverter preinstalled on rear side of DC module. This eliminates any further requirement of connecting micro-inverter to DC module. The working principle of an AC module is as follows: During daytime, an AC module will convert incident solar irradiation to DC power which will be converted to AC power via micro-inverter that can be consumed by home electrical appliances or can be supplied to utility. The LED on the micro-inverter will illuminate in red if it is not connected to the grid. Power line communication (PLC) serves as communication means for data collection from AC module between micro-inverter and communication gateway box. The communication gateway box will send data to web server through home Wi-Fi or LAN cable. The daily, monthly and annual energy generation data can be accessed via the online monitoring app. The communication gateway box along with all required cabling and other accessories will be provided by the installer.

Guidelines for installing AC modules :

AC modules need to be connected with appropriate AC cables and accessories. It is advisable to installer not to cut or alter any connectors or cables attached to modules. For proper air circulation on the rear side of AC module, it is recommended to install AC module with a gap of at least 10 cm (4 inches) between roof surface and module rear side. In order to ensure proper fixation and reliable connection, the AC module frame and mounting racking systems needs to be adequately fastened to prevent loosening during module operation which may result in module damage or operating hazard issue. The recommended torque value for AC modules fixation using bolts is between 4-5Nm. AC modules needs to be installed on racking system with a minimum recommended gap of 6 mm (0.236 inches) between two individual modules. The minimum standoff height recommended is 1.5 in (3.8 cm). If other mounting means are employed, this may affect the UL Listing or the fire class rating for the module. The modules have been evaluated by UL for a maximum positive or negative design loading of 30 psf, negative design loading of 30 psf for bolts and clamps installation method. AC modules need to be mounted with racking and mounting products certified and listed for system fire class rating in accordance with UL1703 edition 2014 and UL2703 edition 2014. It is recommended to use proper AC transition cable adaptor when transitioning from AC module cabling system to other wiring methods. The AC modules are connected with micro inverters which is compatible with 240VAC/120VAC and 208VAC/120VAC. and frequency. It is highly recommended not to install AC modules at low inclination angles which may result in dirt accumulation or build-up on front glass. This may lead to performance degradation in module operation over further course of operation.

While installing AC modules, it is to be noted that the grounding is achieved through securement to the array frame. The array frame shall be grounded in accordance with NEC guidelines, the instructions for the same have been mentioned in detail in wiring section of this installation manual.



Guidelines for mounting AC photovoltaic module :

01) Take the rail on which PV module will be mounted (Refer Fig. 1)



(Fig. 1)

03) Insert mid clamp in rail (Refer Fig. 3 & 4).



(Fig. 3)



(Fig. 4)

05) For each mid clamp, fit one side (two teeth) of each clamp over the respective adjacent frame edge of the two modules (Refer Fig. 6 and 7).



(Fig. 6)



(Fig. 7)

02) Insert T-bolt into side of rail and rotate and fix the L-foot (Refer Fig. 2).



(Fig. 2)

04) Now place the PV module on rail as shown in (Fig. 5)

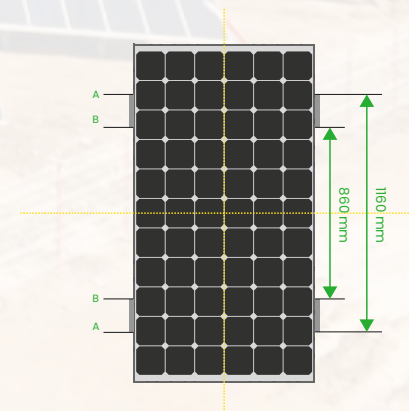


(Fig. 5)

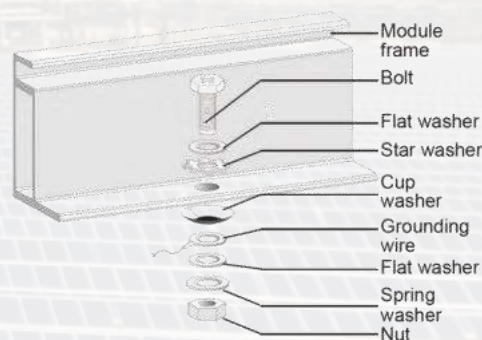
After fixing and tightening, the AC module mounting on rails will be completed.

Please note : the maximum allowable test load is mentioned in below table.

Module orientation	Rail Mounting Range (mm)	Test Load (Pa)
Portrait	A-B=860-1160	+7000/- 4000

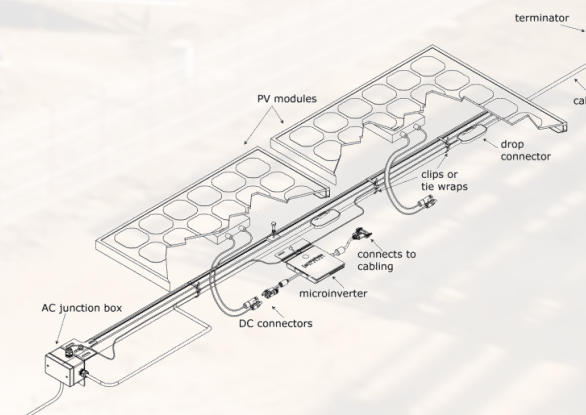
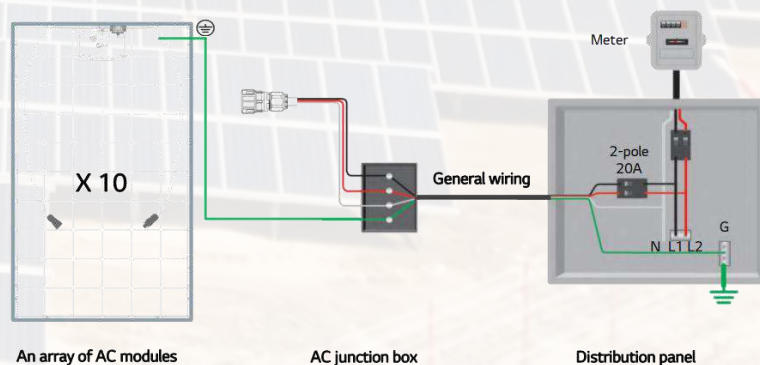


Electrical connection of AC modules & Racking System



All AC cable connectors need to be installed under the AC modules to ensure preventing direct exposure to sun and rain. AC cables need to be kept away from ground or roof surface. Use proper cable clips for attaching AC cables on structure/racking system. The sizing of AC cables needs to be finalized as per NEC2014 guidelines.

Connection of AC modules to AC junction box and distribution panel:



The cable is installed by simply rolling out the desired length of cable and cutting it to size. One end is wired directly into the junction box at the head of the branch circuit, eliminating the need for a separate AC interconnect cable. The other end is sealed from the environment using a Branch Terminator. The micro-inverter AC cable connectors are then plugged into the regularly-spaced connectors.

The gap between connectors on the cable can be either 1.025 meters (40") or 1.7 meters (67"). The 1.025 meter spacing is best suited for connecting PV modules installed in portrait orientation, while the 1.7 meter gap is best suited to PV modules installed in landscape orientation.

The voltage types are either 240VAC split phase or 208VAC three phase. For residential applications, 240VAC includes four conductors. This cabling should also be used for split phase 208VAC applications. Three-phase 208VAC cabling includes five conductors and is used for commercial installations.

Proper transitioning cable usage is recommended for connecting array of AC modules with AC junction box. Wiring must be compliant with NEC Article 705. Grounding methods must be compliant with NEC Article 250.

Bolting mechanism consists of bolts fixation using manufacturer holes provided on AC module frame to the PV racking system. The guidelines mentioned above consists of usage of bolts and mid-clamps for AC modules installation. However, AC modules can also be mounted only using clamps or fixing plates. In both the cases, the installation guidelines needs to be followed as per our instructions combined with bolts and/or clamp manufacturer's specifications. Our detailed guidelines for mounting with bolts/clamps is mentioned in section 7.1 A and B.

If the modules installation is likely to be affected by frequent and/or extreme windstorms or hailstorms, further suitable module support will be required to provide adequate support to module to prevent any module damage.

Connection guidelines for AC cable connectors:

While connecting AC cable connectors, identify "Fool-proof system" on each AC cable connector. Secure connection of AC cable female connector to AC cable male connector is only possible when "Fool-proof System" is properly matched.

One connector needs to be fully inserted into the other connector until the sound like click is heard for ensuring proper fixation. For IQ Cable with 12 AWG stranded conductors designed with NEC standard and using a 1.25 safety factor, 16 A per phase is calculated as the maximum current according to NEC requirements. Breaker selection should be decided based on "Circuit current < Breaker rated current < Cable current capacity".

The maximum output current from one AC module is 2 Amperes and maximum number of AC modules that can be connected in parallel to single phase 240 V system is 10 AC modules. Based on this system design, we recommend circuit breaker (overcurrent protection device) rated current capacity of 20-25 Amperes and trunk cable current capacity of 25A and above.

Usage of a suitable multimeter is recommended to measure phase and line-to-line voltage across L1, L2 and neutral.

If the AC distribution system have 240VAC for L1-L2 and 120VAC for L1-N & L2-N then AC modules should not be connected more than 10 AC modules per a 2-pole 20AMP circuit breaker. If the AC distribution system have 208VAC for L1-L2 and 120VAC for L1-N & L2-N then AC modules should not be connected more than 8 AC modules per a 2-pole 20AMP circuit breaker. If the AC distribution system has 208VAC, three phase (L1, L2, L3 and 120V Line to N) then AC modules should not be connected more than 15 modules (not more than 5 modules per phase). A 3 pole 20A circuit breaker shall be used.

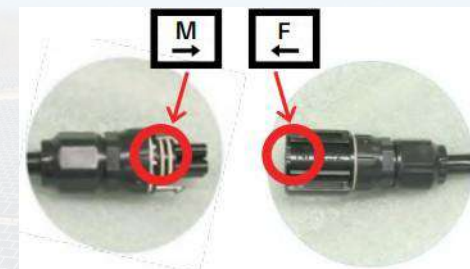
Important safety instructions:

In addition to the safety instructions mentioned in section 4 of this installation manual, below mentioned are some additional safety instructions that needs to be followed while installing and handling AC modules. Failure to comply may result in equipment damage or fatal injury to operating personnel.

Do not use or install AC modules if the module is broken or damaged. AC modules must be stored in original packing before installation. Artificially concentrated sunlight shall not be directed on the module. We recommend that for proper operation, the AC module or AC module arrays should be connected only to a dedicated branch circuit. Removing the micro-inverter cover may void the warranty, no serviceable parts inside. Do not bend the AC cables, while under stress, may result in module damage. Do not install AC modules where maximum ambient temperature exceeds 65°C (149°F). In an environment with frequent lightening or storms, an additional grounding i.e. direct connection of AC module system to ground may be required to be installed by the EPC contractor. It is always recommended to pre-check all the installation requirements and guidelines as per the local electric codes.

The connectors for AC modules are weatherproof and sunlight rated AC locking connectors which after connected require the use of a tool to disconnect module to module connections. So trained qualified personnel with proper training and certifications are required for disconnecting the modules while under load. AC connectors are rated and tested to interrupt load current but we recommend to always open the dedicated branch circuit protector to remove power before plugging or unplugging any connectors. Do not disconnect the cable connectors while in operation to prevent any risk of electric shock or arcing.

If any damage occurs to the AC module during O&M or during servicing, the damaged modules must be handled with appropriate protective equipment.



7.2 GROUNDING

The module is considered to be in compliance with this standard only when the module is mounted in the manner specified by the mounting instructions. A module with exposed conductive parts is considered to be in compliance with this standard only when it is electrically grounded in accordance with the manufacturer's instructions and the requirements of the National Electrical Code, ANSI/NFPA 70 (2014-2017)."

Module frames should be connected to an earth ground for safety and protection from lightning. Good connection between the grounding hardware is essential for an effective ground. The anodization on a Module frame provides a coating to minimize the corrosion due to weather and it acts as a barrier that reduces the effectiveness of the grounding connection. For an adequate ground, the grounding hardware should pierce the anodization layer.

Proper grounding is achieved by bonding the Module frame(s) and all metallic structural members together continuously using a suitable grounding conductor. The grounding conductor or strap may be copper, copper alloy, or any other material acceptable for use as an electrical conductor. The devices have to be installed in accordance with the grounding device manufacturer's specified instructions. The grounding must be cross verified for its proper continuity.

Note: -

"Please avoid negative bias of the cells with respect to the grounded frames".

Solar modules can be installed with the use of third party listed grounding devices for grounding the metallic frames of PV modules. The devices have to be installed in accordance with the grounding device manufacturer's specified instructions



We also recommend using the following methods to ground installation properly under UL investigation.

Method 1: Tyco grounding bolt # 2058729-1:

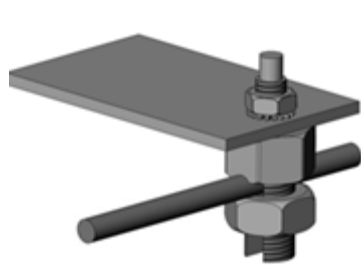
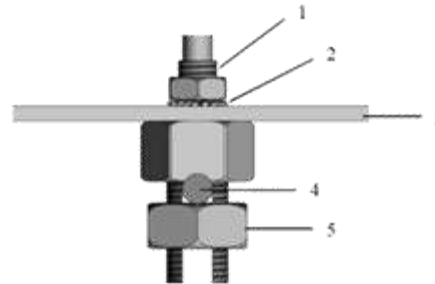


Fig: Grounding bolt # 2058729-1

- 1) Wire bolt and slot
- 2) Mounting wash hex nut
- 3) Aluminium frame



- 04) 4 to 16 mm² cable
- 05) HEX nut

- » Tyco grounding hardware comes in a package that includes the grounding bolt, mounting and grounding hex nut. Electrical contact is made by penetrating the anodized coating of the aluminium frame and tightening the mounting hex nut (come with the star washer) to the proper torque of 25lbf.in. Grounding wire size (6 to 12 AWG solid bare copper) should be selected and installed underneath the wire binding bolt.
- » The wire binding bolt should be tightened to the proper torque of 45lbf.in

Method 2: Grounding bolt #1954381-2:

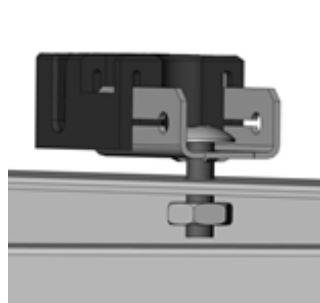
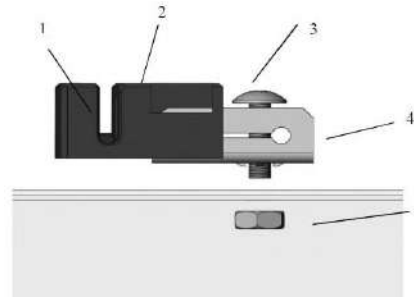


Fig: Grounding bolt # 1954381-2

- 1) Wire slot (available for 4-6 mm² cable)
- 2) Slider
- 3) Bolt



- 04) Base
- 05) Nut

Tyco grounding hardware comes in a package that includes the grounding bolt, mounting and grounding hex nut. Electrical contact is made by penetrating the anodized coating of the aluminium frame, and tightening the mounting hex nut (come with the star washer) to the proper torque of 25 in lb. Grounding wire size (6 to 12 AWG solid bare copper) should be selected and installed underneath the wire binding bolt. The wire binding bolt should be tightened to the proper torque of 45 in lb. The Tyco grounding bolt is only listed for use with 6 to 12 AWG bare solid copper wire.

Method 3: ERICO grounding bolt # EL6CS

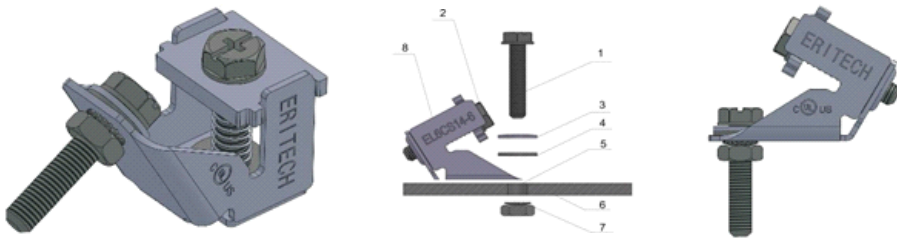


Fig: ERICO grounding bolt # EL6CS

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

- » The lug should be installed on a surface that is larger than the bottom surface of the lug
- » The lug should be installed in the grounding holes provided on the PV module
- » Machine bolt A should be torqued to 35 in lb, to secure the grounding bolt to module frame
- » The grounding bolt is only listed for use with 6-12 AWG bare solid copper wire
- » For proper wire binding, machine bolt B should be torqued 35 lb



7.3 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
- » PV modules can be connected in Series to have an increase in the Operating Voltage. The positive connector plug of module is connected to the negative connector plug of another module until there is a click sound. Only if there is a click sound assumes the modules are connected.
- » Product can be irreparably damaged if an array string is connected in reverse polarity to another i.e. 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 seen or any difference of more than 10 V is observed, the string configuration connection needs to be checked and connected appropriately
- » WAAREE Solar modules are provided with standard Cables with a 4 mm² cross-sectional area and are rated upto 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,

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

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

X – No: modules which are connected in series

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

β – Thermal coefficient of open circuit voltage for the module in Percentage

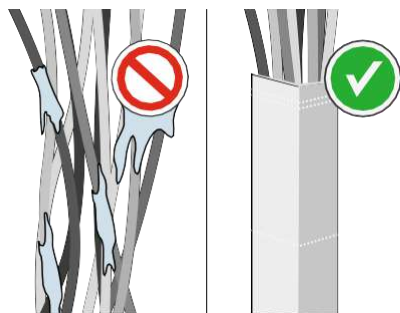
T_{min} – Minimum ambient temperature of the location of the plant

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

$I_{m\alpha}$ – 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

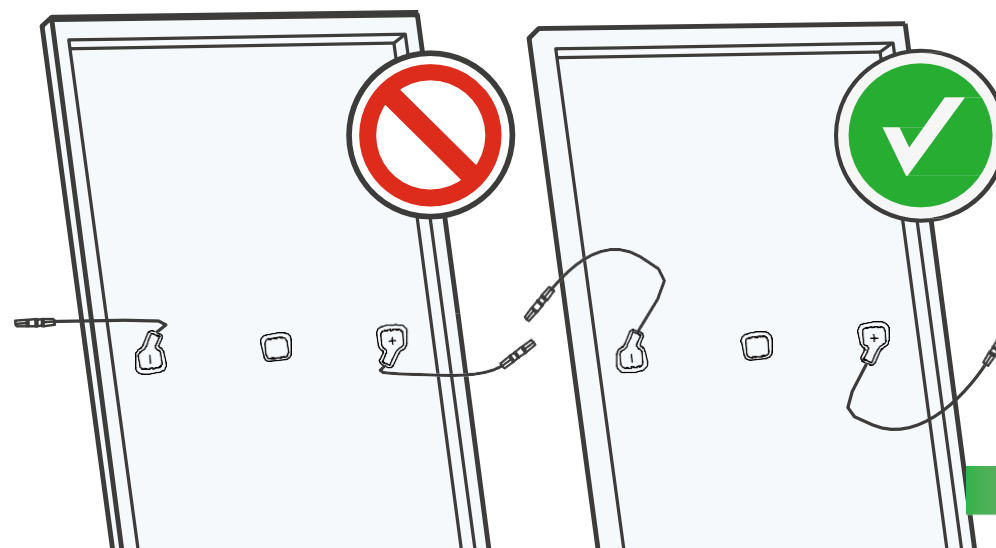
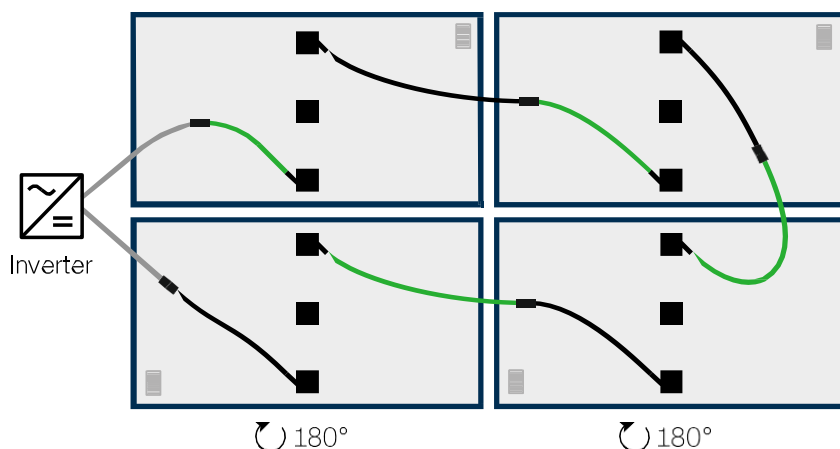
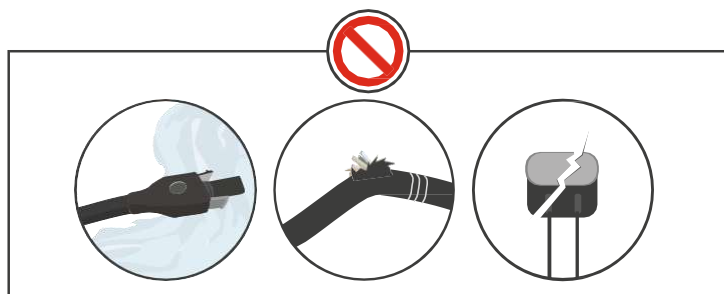
I_m – The MPP operating current at 0% bifacial gain (in case of bifacial module) (Refer to the Data Sheet)





The minimum bending radius cables should be 43mm(1.69in).

- » WAAREE Modules contain factory installed bypass diodes. If the Modules are incorrectly connected to each other, the bypass diodes, cables or junction box may be damaged.
- » When reverse currents can exceed the value of the maximum protective fuse, a properly rated and certified over current device (fuse or circuit breaker) must be connected in series with each Module or string of Modules.
- » Match the polarities of cables and terminals when making the connections; failure to do so may result in damage to the Module.
- » Connecting Modules in reverse polarity to a high current source, such as a battery, will destroy the bypass diodes and render the Module inoperative. Bypass diodes are not user replaceable.
- » The junction box, cable and connectors shall not be altered in any case. Modules with a suspected electrical problem should be returned to WAAREE for inspection and possible repair or replacement as per the warranty policy shall be provided by WAAREE.



8. 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 be efficiently connected into grid.



Caution

Solar module 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 WAAREE, 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. WAAREE will not be responsible for any electrical accidents occurring in power plants using WAAREE Solar modules.

8.1 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.

8.2 INVERTER SELECTION 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 IEC norms and regulations, WAAREE modules normally do not need to be electronically connected to earth and can operate with either galvanically isolated (with transformer) and transformer less inverters. If the system is located in hot and very humid locations then galvanically isolated Inverters with Transformers must be used and the negative pole of the array must be connected to earth. It is recommend to adopt inverter negatively earthed installation to avoid the PID effect. If a Transformer less Inverter is used in hot humid climatic locations, The Installer should ensure the right active negative earthing kit is to be installed by consulting and having assurance from the inverter supplier.

8.3 BYPASS DIODES

- » WAAREE Solar PV modules are equipped with bypass diodes in the junction box. This minimizes module heating and current losses. Do not try to open the junction box to change the diodes even if they malfunction.
- » In a system using a battery, blocking diodes are typically placed between the battery and the PV module output to prevent battery discharge at night.



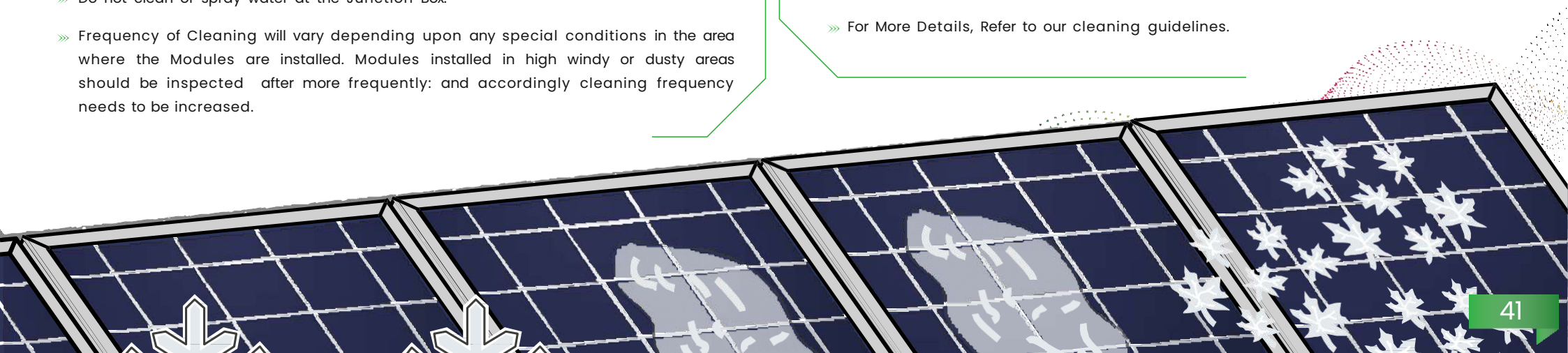
9. MAINTENANCE & CLEANING OF PV MODULE

- » It is common for dust and dirt particles to accumulate on the surface(s) (front and back in case of bifacial module) of the Module. 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.
- » PV Module Cleaning should be done only by properly trained personnel who understand the risks of applying water to electrical components.
- » 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.
- » 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.
- » 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.
- » 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 after thermal stress in module: which may result in micro-cracks in glass or cells in module..
- » 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.
- » 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.
- » High pollution or close to large bird populations will require more regular cleaning.
- » The back surface of the monofacial module normally does not need to be cleaned but if needed, avoid the use of any sharp projects that might penetrate the substrate material.
- » 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.
- » When using water, RO water provides the best results. In absence of RO water, tap water with low mineral content (total hardness <75 mg/l) or deionized water may be used. Calcium should not exceed: 75 mg/ml. Do not use solutions containing hydrochloric acid, D-Limonene, ammonia or sodium hydroxide.
- » In case if soft water (with low mineral content) is not available, Module can be dry cleaned with the help of a soft cloth or with soft sponge to remove dirt, dust. One can also use wet cloth, sponge to clean dirt which is not easily removed by dry cleaning.
- » 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 areas should be inspected after more frequently: and accordingly cleaning frequency needs to be increased.

- » If excessive soiling is present, a non-conductive soft brush, sponge, or other mild agitating method may be used before using water. Ensure brushes or agitating tools are not abrasive to glass.
- » Module damage that arises as a result of improper cleaning will not be warranted by WAAREE
- » To avoid dirt accumulation or white efflorescence due to water accumulation, do not install PV Modules horizontally.
- » We strongly recommend cleaning of our modules on regular basis before and post installation, during commissioning and in regular operation.
- » Modules when remained uncleaned for longer duration may result in formation of hotspots and other anomalies like cell burnt issues etc. which all contribute to module reliability issues. Please ensure that module front and rear surface are thoroughly cleaned for efficient generation and for prolonged useful module life.
- » The soiling loss measurement needs to be performed on regular basis and decide cleaning frequency accordingly. Please ensure, in areas with snowfall or where frost accumulation may be possible, the modules needs to be cleaned on timely basis (atleast once in a month) to avoid any damage due to continuous exposure to extreme weather conditions.
- » If modules are intended to operate with single axis trackers, after installation and before commissioning, the modules must be stowed at 10-20 degrees based on design and location so as to avoid water accumulation or logging on bottom edge of modules which may further lead to module damage.
- » The maximum water pressure allowable for cleaning PV module is 35 bar (3.5 MPa). This pressure indicates the force with which water will hit the modules.
- » For More Details, Refer to our cleaning guidelines.





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 Mail us for more details