

**WAAREE**<sup>®</sup>

*One with the Sun*



**INSTALLATION**

**MANUAL**

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## 1. Introduction

This manual contains information regarding installation, operation, maintenance and safe handling of WAAREE Bifacial Glass to Glass 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 expressly 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.**

This photovoltaic module produces electricity from both the sides when exposed to the sunlight, even at low light levels or when other sources illuminate its faces. The open circuit voltage from the front face of Module is ~50 V DC. 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 rubber gloves and boots with maximum working voltage not lower than 1500 V DC.
- 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.
- Cover the entire front & back surface of the Bifacial PV Module with a dense, opaque material such as cardboard box, during installation and handling of the Modules.  
**Important:** Waaree's Bifacial Modules produce Voltage when exposed to light also on backside.
- 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, split-ring lock washers, flat washers and the like) 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  $\pm 5$  percent of measured values at Standard Test Conditions of  $1000 \text{ W/m}^2$ ,  $25^\circ\text{C}$  cell temperature and AM 1.5 solar spectral irradiance.
- The module is considered to be in compliance with UL61730 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 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.
- 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 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 edges, wearing non-slip gloves (to avoid injury by a slipped Module, or by the edge, and so on).
- Only PV Modules with the same cell type and size should be connected in series.
- 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 treat back and/or front surface of the Module with paint and adhesives, such cases will void Warranty.
- Do not artificially concentrate light on the 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, solar PV 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.
- The fire rating of the module is valid only when mounted in the manner specified in the mechanical mounting instructions.
- 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

- The pallet packaging is not water or weatherproof. Prior to installation, and to avoid any damage or degradation to the packaging or panel components, pallets and panels must be stored in a protected environment, ideally in internal storage conditions, where it is shielded from the elements, e.g., rain, dust, direct sunlight. If overnight external storage in an uncontrolled environment is unavoidable, the panels and the pallet packaging must be protected from direct exposure to the elements and from contact with the ground, including earth, mud etc.
- If pallets are stored temporarily outside then place a protective covering over the pallet to protect it from direct weathering and Do NOT stack more than the maximum amount of allowable pallets on top of each other.
- The handling of Bifacial / Glass –glass Modules requires great diligence. Therefore, caution is required while unpacking, transporting and temporarily storing these Modules.
- Do NOT use a knife to cut the zip–ties, always use wire cutting pliers.
- Do NOT place modules directly on top of each other. Do not carry the Module on Head.
- When carrying the bigger Module, two or more people should carry it by its edges properly and wear non–slip gloves (to avoid injury by a slipping Module). Do not leave the Module unsupported or unsecured prior to installation.
- Store Modules in a dry and ventilated room.
- 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.
- A Module with broken glass cannot be repaired and must not be used since contact with any Module surface can produce electrical shock.
- At the installation site, take care of Modules and ensure that their electrical contacts clean.
  
- Broken or damaged Modules must be handled carefully and disposed 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.

**CAUTION: In any case DO NOT STAND OR STEP on the modules, Do not drop or place objects on the module(s) (such as tools), do not thump / give extra pressure on the surface of the module(s) as localized high loads can induce severe micro –cracks at the cell level, which in turn may compromise module reliability. Failure to comply with above caution will void WAAREE’s warranty**



Figure 1: Wrong methods of installing a solar PV module

## 5.1 Module Identification

Each module has a unique serial number, which is laminated between the glasses. Please do not tamper with the serial number of the module in any ways 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 module.

**Warning: 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.**

## 5.2 Maximizing Power Output Through Bifaciality

Output power is increased proportionally to the light received by rear side of modules. The available light that hits the back of the module is directly related to the height (and tilt angle) of the module installed over the surface.

- Choose the highest possible Surface Reflectivity/Albedo, such as a white roof or white ground surface covering.
- Avoid shading the back side of the module by the support rack.
- Elevate the modules above the mounting surface at an appropriate height to avoid loss of irradiance.
- With tilted rooftop installation, ensure an appropriate ventilation on back to reduce an accumulation of heat with adverse effects on the performance.
- It is recommended that a proper simulation is carried out before setting up a power plant.

## 6. Environmental Consideration And Site Selection

WAAREE Solar modules are certified for IEC 61215, IEC 61730-I &II, IEC 62804. The Environmental Conditions of the module are as below:

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

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 10% of the values measured at Standard Test Conditions (STC) of 1000W/m<sup>2</sup> irradiance, 25 °C cell temperature and AM 1.5.

## 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 to design based on local situations to find out the optimum one.
- 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 9:00 A.M. to 3.00 P.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 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 Specifications

MODULE SPECIFICATIONS UNDER STC CONDITION								
Model Type	Module Technology	Number Of Cells	Maximum Power (Pmax) [W] Tolerance ± 5%	Open Circuit Voltage (Voc) [V] Tolerance ± 5%	Maximum Power Voltage (Vmp) [V]	Short Circuit Current (Isc) [A] Tolerance ± 5%	Maximum Power Current (Imp) [A]	Maximum Over Current Protection [A]
Bi-11-360	Mono crystalline Bifacial	72	360	47.41	39.07	9.71	9.22	25 A
Bi-11-365	Mono crystalline Bifacial	72	365	47.72	39.34	9.77	9.28	25 A
Bi-11-370	Mono crystalline Bifacial	72	370	48.04	39.60	9.84	9.35	25 A
Bi-11-375	Mono crystalline Bifacial	72	375	48.35	39.85	9.90	9.42	25 A
Bi-11-380	Mono crystalline Bifacial	72	380	48.67	40.11	9.97	9.48	25 A
Bi-11-385	Mono crystalline Bifacial	72	385	48.98	40.36	10.03	9.55	25 A
Bi-11-390	Mono crystalline Bifacial	72	390	49.29	40.61	10.09	9.61	25 A
Bi-12-300	Mono crystalline Bifacial	60	300	39.50	32.67	9.66	9.20	25 A
Bi-12-305	Mono crystalline Bifacial	60	305	39.77	32.93	9.72	9.28	25 A
Bi-12-310	Mono crystalline Bifacial	60	310	40.03	33.19	9.79	9.35	25 A
Bi-12-315	Mono crystalline Bifacial	60	315	40.29	33.45	9.85	9.43	25 A
Bi-12-320	Mono crystalline Bifacial	60	320	40.56	33.70	9.92	9.51	25 A
Bi-12-325	Mono crystalline Bifacial	60	325	40.82	33.95	9.98	9.58	25 A



MODULE SPECIFICATIONS CONSIDER BNPI CONDITION

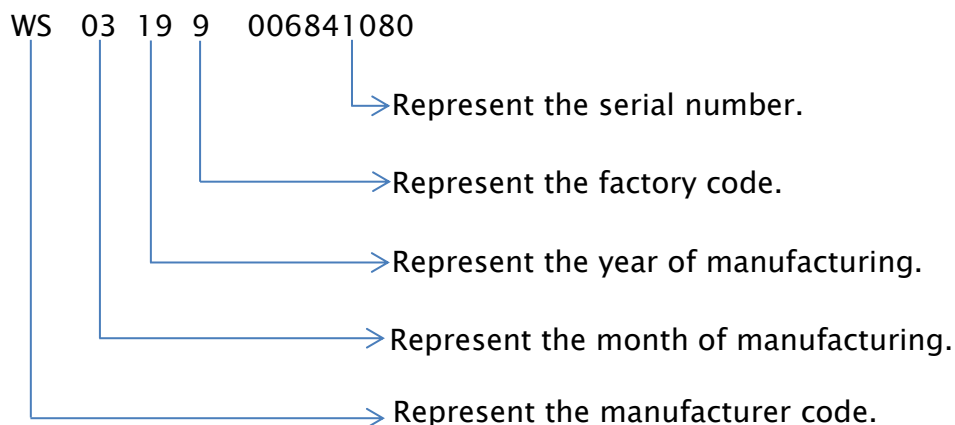
Model Type	Module Technology	Number Of Cells	Maximum Power (Pmax) [W] Tolerance ± 5%	Open Circuit Voltage (Voc) [V] Tolerance ± 5%	Maximum Power Voltage (Vmp) [V]	Short Circuit Current (Isc) [A] Tolerance ± 5%	Maximum Power Current (Imp) [A]	Maximum Over Current Protection [A]
Bi-11-360	Mono crystalline Bifacial	72	390	47.67	39.28	10.60	9.93	25 A
Bi-11-365	Mono crystalline Bifacial	72	395	47.99	39.55	10.65	9.99	25 A
Bi-11-370	Mono crystalline Bifacial	72	400	48.30	39.82	10.70	10.05	25 A
Bi-11-375	Mono crystalline Bifacial	72	405	48.62	40.08	10.74	10.11	25 A
Bi-11-380	Mono crystalline Bifacial	72	410	48.94	40.33	10.79	10.18	25 A
Bi-11-385	Mono crystalline Bifacial	72	415	49.25	40.58	10.85	10.25	25 A
Bi-11-390	Mono crystalline Bifacial	72	420	49.57	40.84	10.89	10.30	25 A
Bi-12-300	Mono crystalline Bifacial	60	325	39.72	32.85	10.58	9.91	25 A
Bi-12-305	Mono crystalline Bifacial	60	330	39.99	33.11	10.65	9.97	25 A
Bi-12-310	Mono crystalline Bifacial	60	335	40.25	33.37	10.72	10.06	25 A
Bi-12-315	Mono crystalline Bifacial	60	340	40.52	33.63	10.79	10.12	25 A
Bi-12-320	Mono crystalline Bifacial	60	345	40.78	33.89	10.86	10.19	25 A
Bi-12-325	Mono crystalline Bifacial	60	350	41.04	34.14	10.93	10.26	25 A

Module technology	Temperature Coefficient	NOCT
Mono crystalline Bifacial	$\alpha = 0.05 \%/^{\circ}\text{C}$	46 ± 2 °C
	$\beta = -0.27 \%/^{\circ}\text{C}$	
	$\gamma = -0.37 \%/^{\circ}\text{C}$	

- Please refer latest Module datasheet for Specifications

### 6.3 MODULE BARCODE SERIAL NUMBER TRACEABILITY

For Example :- WS03199006841080

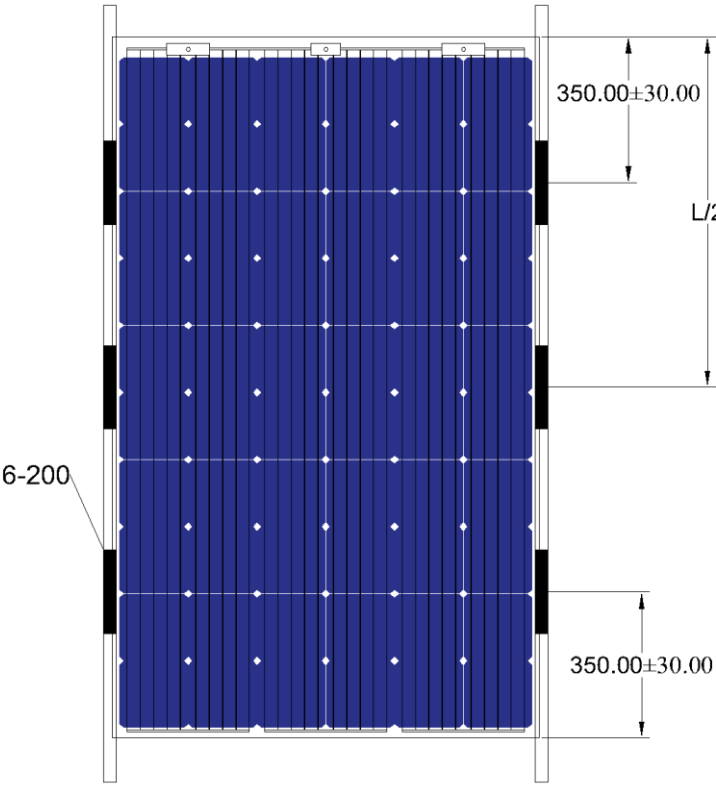
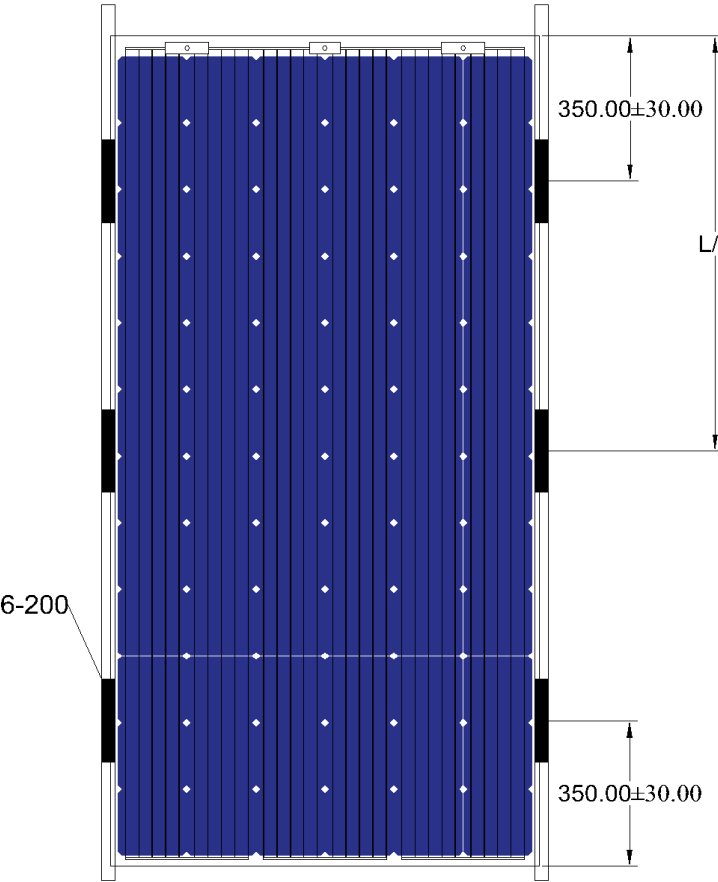


## 7. Installation Guide

### 7.1 Mounting Instruction

Modules can be installed to the racks by clamps only. Modules must be installed according to the following examples and recommendation.

The following lower/normal level of load conditions is applicable to the installation in most environment: the maximum design static load on the backside of the double glass modules is 1600 Pa (i.e. wind load), and the maximum design static load on the front of the double glass modules is 3600 Pa (i.e. wind and snow load) with a safety factor of 1.5. The module are hence tested at load of 5400 Pa (at front side) & 2400 Pa (at back side). It is recommended that the both 72 full cell bifacial module & 60 full cell bifacial module use a 6 point clamping method for installation as shown in Figure below.

3600 Pa (Factor of safety - 1.5) Only for clamp length 200mm	3600 Pa (Factor of safety - 1.5) Only for clamp length 200mm
 <p>The diagram shows a 60 full cell bifacial glass module mounted on a rack. It features 6 clamps (labeled '6-200') along the top and bottom edges. Dimension lines indicate a height of <math>350.00 \pm 30.00</math> mm from the top and bottom edges to the center of the module. The total height is labeled as <math>L/2</math>.</p>	 <p>The diagram shows a 72 full cell bifacial glass module mounted on a rack. It features 6 clamps (labeled '6-200') along the top and bottom edges. Dimension lines indicate a height of <math>350.00 \pm 30.00</math> mm from the top and bottom edges to the center of the module. The total height is labeled as <math>L/2</math>.</p>
<p>Figure 2: Position requirements for clamps installation of 60 full cell bifacial glass to glass modules</p>	<p>Figure 3: Position requirements for clamps installation of 72 full cell bifacial glass to glass modules</p>

The use of frameless bifacial modules requires frameless mounting system that grabs the edge of the module with a pressure clamp that is lined with rubber pads (EPDM, etc). The clamps must overlap from the edge of the module by at least 10mm but should avoid shading the cells in the module. The applied torque used to attach the clamps to the module/racking should refer to the mechanical design standard for the specific bolt in use. When installing modules in an array, please allow for a minimum lateral air gap of at least 10mm between the exposed edges of the adjacent modules to account for thermal expansion and contraction of PV system elements in the field. Module need metal clamp to be fixed on the racks. WAAREE recommends you use clamps as below Specifications or clamps approved by system installer:

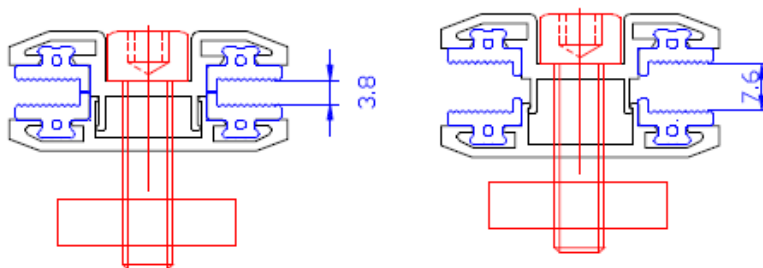
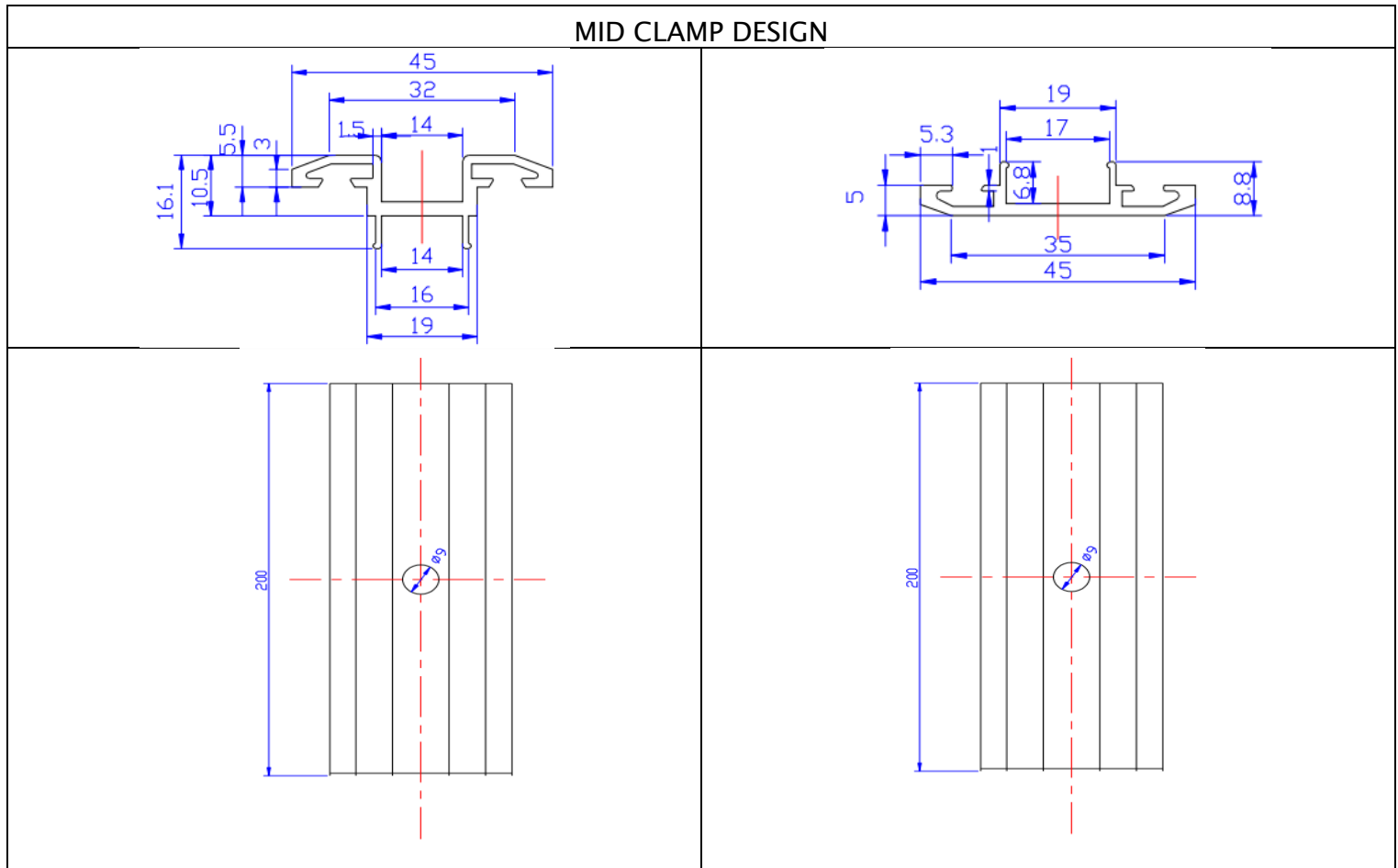
Length for bifacial glass to glass module: 200mm, Thickness:  $\geq 3\text{mm}$

Material: Aluminium alloy, 6063-T5

Supplier: Jiangsu Yuejia Metallic Technology Co., Ltd

Rubber washer: Ethylene Propylene Diene Monomer (EPDM)

Bolt: M8 stainless steel bolt Torque range : 16-20 N.M



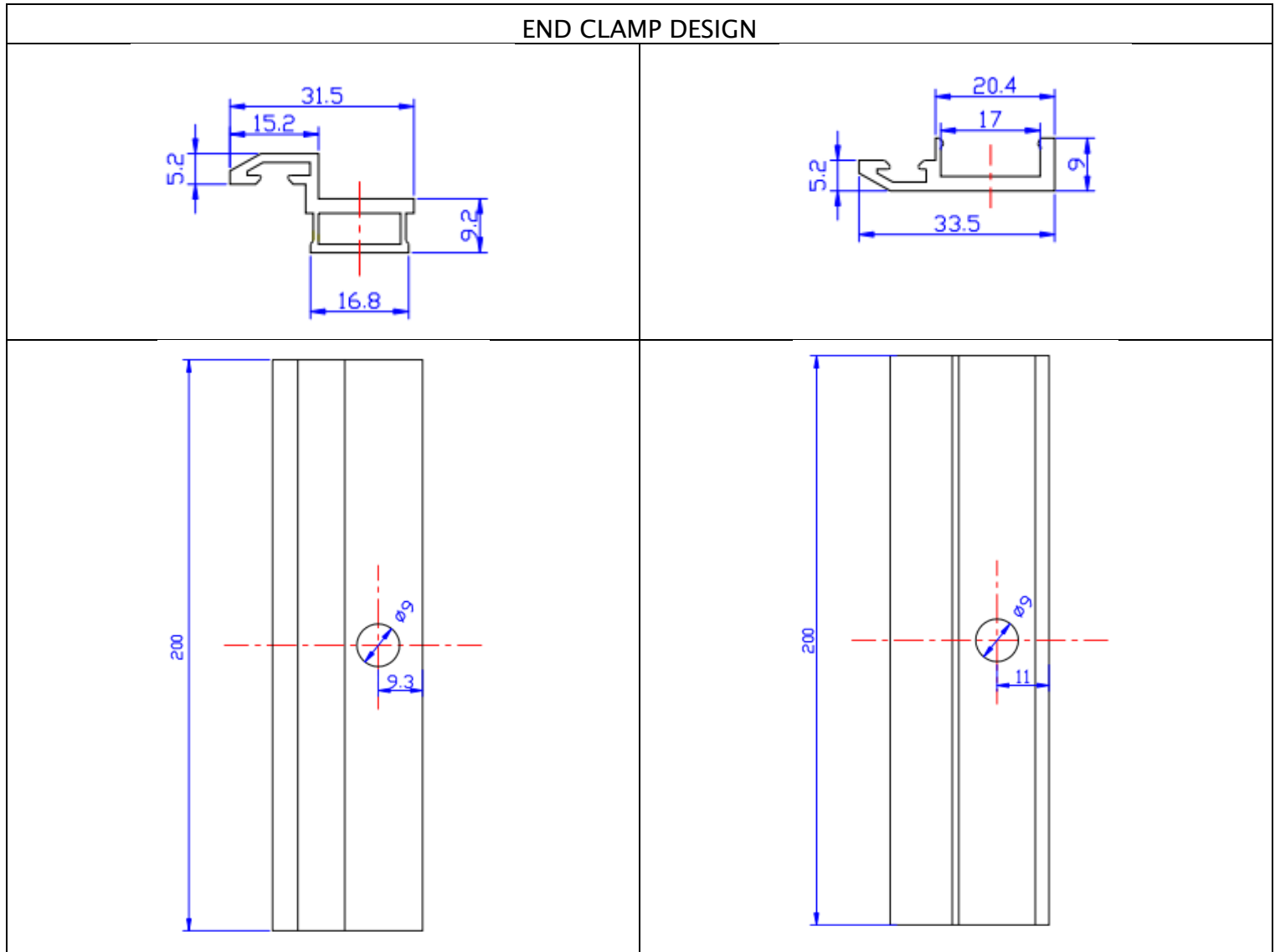
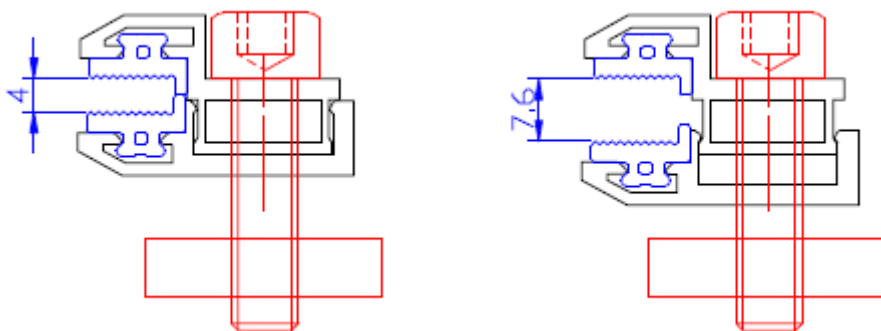


Figure 4: Cross section of clamp structure for frameless bifacial glass to glass module



The modules clamps must not contact the glass directly or deform/damage the glass in any cases, clamp should be embedded with the rubber washer, which plays a buffer function when install double glass module and the contact area of clamp with the glass surface must be smooth, otherwise may damage the modules. Avoid shading effects from the modules clamps. The EPC/installer needs to make sure that the bolt is not too high such that it would cast shadow over the solar module.

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.

## 7.2 Wiring Instruction

- 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
- Add the following new paragraph at the end of the first paragraph: "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)
- 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 mm<sup>2</sup> cross-sectional area and are rated for 1500V (IEC and UL) for maximum system voltage, 90°C and are UV resistant. Ensure the cables are not exposed to water logged areas.
- Actual Maximum system voltage of Installed system can be calculated as per below formula to identify the recommended maximum series/parallel module configurations,  

$$\left[ \frac{1500V}{(1.25 \cdot V_{oc})} \right] / [1 \text{ or fuse rating} / I_{sc} + 1]$$

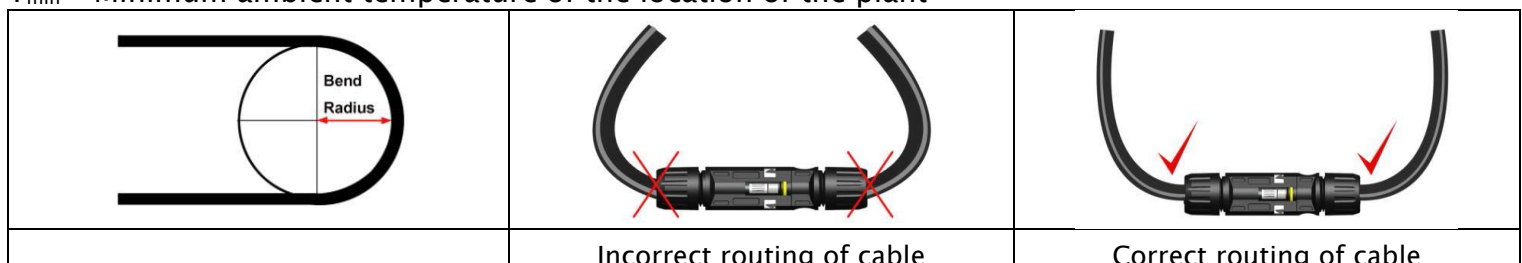
$V_{oc}$  – Open circuit voltage of each module (Refer to the Data Sheet)  
 $I_{sc}$  – Short circuit current of each module (Refer to the Data Sheet)
- The maximum voltage of the system should be lesser than the certified system voltage (typically 1500V) or the maximum input voltage of the inverter. Since  $V_{oc} \propto (1/T)$ , the open circuit voltage of the array needs to be calculated at the lowest ambient temperature for the location of power plant. This can be done using the formula below,  

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

Where:

  - 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 (refer the datasheet)

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



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

- WAAREE Modules contain pre- installed bypass diodes. If the Modules are incorrectly connected to each other, the bypass diodes, cables, or junction box may be damaged.
- As 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.
- **The connectors couldn't be mated with the connectors that are not allowable mated together**

### 7.3 SOLAR MODULE JUNCTION BOX, CABLE'S, BYPASS DIODE, CONNECTOR'S RELATED INFORMATION

Junction box type	Junction box manufacturer	Diode models	Diode models manufacturer	Cable type	Cable manufacturer	Connector type	Connector manufacturer
PV- ZH011C-2X	Zhejiang Zhonghuan Sunter Pv Technology Co Ltd.	30SQ045- SL	Zhejiang Zhonghuan Sunter Pv Technology Co Ltd.	PV Wire, 4mm2	Zhejiang Zhonghuan Sunter Pv Technology Co Ltd.	PV- ZH202B	Zhejiang Zhonghuan Sunter Pv Technology Co Ltd.

## 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 efficiently convert this 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). While we use a 15A fuse in regular power plant, the bifacial module produces excess current. It is thus necessary to refer to the datasheet and design the fuse rating accordingly taking the onsite conditions into consideration.

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 recommended 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 EPC/installer and having assurance from the inverter supplier.

## 8.3 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. Doing so can cause shock/ electrical hazard/ fire outrage in the power plant. It would further render the warranty void of the module.
- In a system using a battery, utilizing a blocking diode is recommended. 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 both front & back surface 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 from both the sides of module.
- 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, 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 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.
- Maintenance should be carried out at least once a year by trained personnel, always wearing rubber gloves and boots with maximum working voltage not lower 1500 V for 1500 V system voltage modules.
- Trim any vegetation which may shade the solar array thus impacting the albedo of the ground and/or its 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 once 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.
- 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.
- 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 more frequently.
- 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.
- For more details, refer to our cleaning guidelines

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