



INSTALLATION MANUAL

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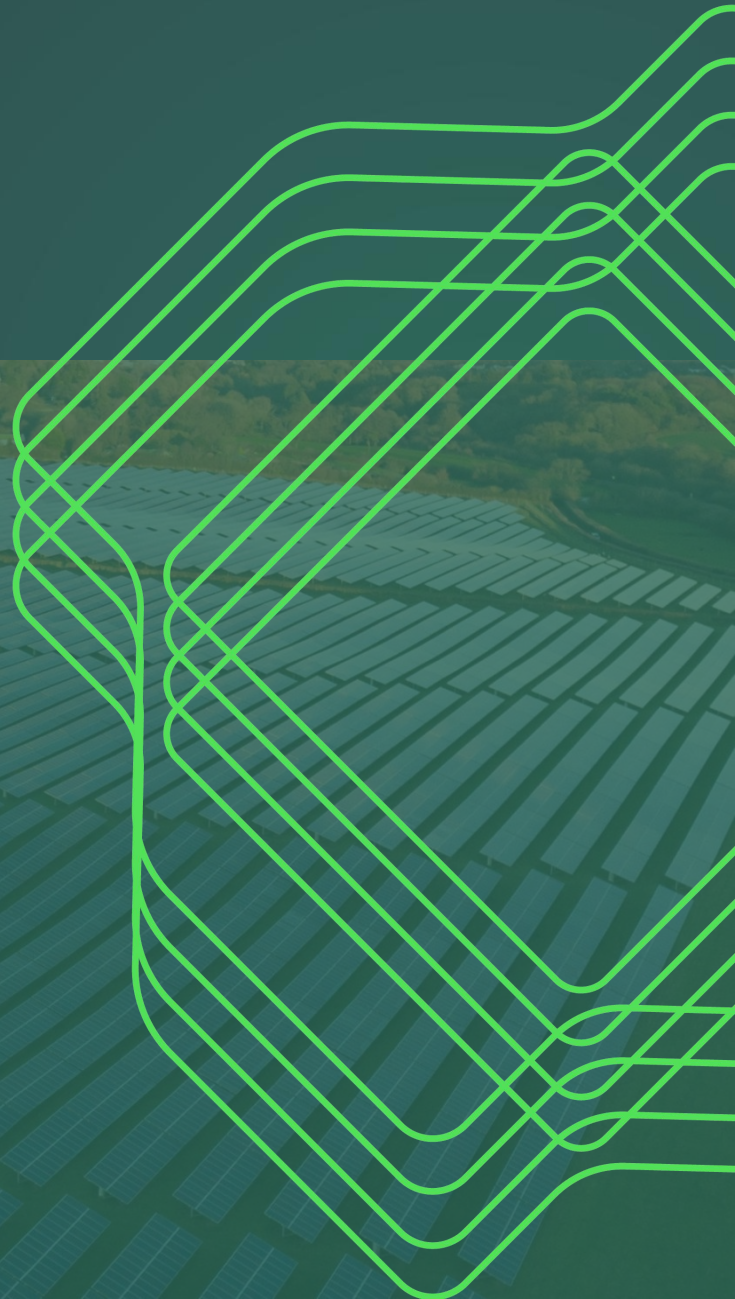


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1. OVERVIEW

Thank you for choosing our products. This manual is exclusively designed for the solar modules, hereinafter referred to as "modules," manufactured by Imperial Star Solar (Cambodia) Co., Ltd, identified as "IMPERIAL STAR SOLAR." It comprehensively addresses installation procedures, operational safety guidelines, and maintenance instructions for IMPERIAL STAR SOLAR modules.

Installation of modules should be undertaken by a qualified professional. It is essential to meticulously read and comprehend this manual before commencing installation. It is imperative that the installer possesses a thorough understanding of the mechanical and electrical prerequisites associated with installation. Failure to adhere to the installation guidelines in this manual may lead to personal injury or property damage. It is strongly advised to retain this manual for future reference in care and maintenance, as well as for use when selling or disposing of modules.

Installers are obligated to strictly adhere to the specifications detailed in the manual, in addition to local laws and pertinent regulations established by authorized agencies. Informing end customers and consumers about these requirements is the responsibility of the installer.

The entirety of the content within this manual is protected by the intellectual property rights of Imperial Star Solar, derived from their extensive technological exploration and accumulated experience over the years.

Disclaimer

This manual does not serve as a quality warranty, and its content should not be construed as such. IMPERIAL STAR SOLAR shall not be liable for any damages arising from the installation, operation, use, or maintenance of the modules in contravention of the stipulations set forth in this manual. Such damages may include but are not limited to module breakdown, physical damage, or associated costs. The use of this module does not grant any customer explicit or implicit patent rights or a patent license.

IMPERIAL STAR SOLAR is not liable for any infringements on third-party patents or other rights resulting from the use of this module. The information presented in this manual is based on the knowledge and experience of IMPERIAL STAR SOLAR, and while it is deemed reliable, the product specifications and recommendations provided (though not limited to these) do not constitute an explicit or implicit warranty

2. PRECAUTIONS

Before undertaking the installation, wiring, operation, or maintenance of the modules, it is imperative that all installation personnel thoroughly read and comprehend the safety precautions outlined in this manual. Even when the module is not actively connected, exposure of the module cell surface to direct sunlight or other light sources generates direct current (DC). Direct contact with wiring components, such as terminals, can lead to severe injury or even death.

The complexity of installation sites, coupled with the substantial size and weight of PV modules, necessitates stringent protective measures under all circumstances. Regardless of the location, timing, or conditions, individuals coming into contact with PV modules must implement appropriate safety precautions. These include, but are not limited to, the use of protective gear such as safety helmets, safety belts, insulated gloves, insulated tools, and insulated shoes. When engaging in tasks such as installation, wiring, grounding, servicing, cleaning, and other tasks, it is crucial to employ the designated electrical safety protection tools to prevent direct contact with modules, mitigating the risk of electric shock and cuts.

To underscore the significance of adhering to recommended precautions, this manual utilizes specific signs for clarification. As shown below, the appearance of such symbols in the manual or at construction sites serves as a clear indication that disregarding these warnings may result in product damage or pose a threat to the personal safety of the installer or user.



2.1. Fire Safety

To enhance safety during the installation and use of modules, it is crucial to avoid the presence of open flames or flammable and explosive materials in the vicinity. In cases where modules are being installed on roofs or buildings, it is crucial to obey local laws and regulations and adhere to building fire safety requirements.

For installations on roofs, a layer of fireproof material with an appropriate grade should cover the roof. Moreover, it is essential to ensure proper ventilation between the module and the mounting surface. Different roof structures and installation methods can impact the fireproof performance of buildings, making it imperative to take precautions during installation to prevent the risk of fire.



Use appropriate module accessories, including fuses, circuit breakers, and grounding connectors. These measures help ensure compliance with local laws and regulations, providing additional protection in the event of an accidental failure that could pose a fire risk.

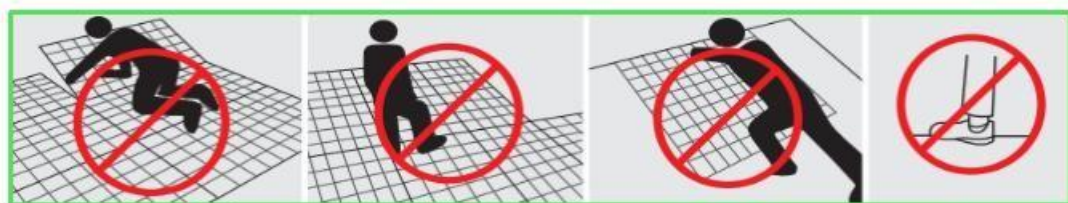
2.2. General Precautions

IMPERIAL STAR SOLAR modules are designed to meet the requirements of IEC 61215 and IEC 61730, specifically classified under Safety Class II.

- All installation work must comply with the local codes and relevant electrical standards.
- Installation of PV modules must be carried out by personnel professionally trained in PV system installation. Operating these systems without familiarity with relevant safety protocols can pose significant risks.
- Restrictive access to the installation and storage areas to authorized personnel only.
- During installation, protective clothing, including but not limited to non-slip gloves and appropriate attire, must be worn to prevent direct contact with 30V DC or higher, as well as to safeguard hands against sharp edges.
- Metallic jewelry should be removed before installation to mitigate the risk of accidental exposure to live circuits.
- In conditions such as rain or dew, when installing modules, precautions such as the use of connector end caps must be taken to prevent water ingress into connectors.
- To minimize the risk of electric shock, it is imperative to utilize insulated tools.
- Do not use or install broken modules.
- Under no circumstances should external or artificially concentrated sunlight be directed onto the front or back face of the PV module.
- Do not contact the module if the front or rear glass is broken to avoid risk of electric shock.
- Do not attempt to repair, disassemble, or move any part of the PV module. The module does not contain any reusable parts.
- Do not connect or disconnect the module when it is energized or connected with an external power supply.

2.3. Handling Precautions

- Do not stand, walk on or lean on the module to avoid damage and personal injury.



- Exercise caution to prevent any damage to the front and back surfaces of the module.

- When handling the output cable, refrain from dragging, scratching, or bending it forcefully or with excessive tightness. Forceful actions may break the cable's insulation, leading to electricity leakage or shock.
- If there is an open fire, please extinguish it with a dry powder extinguisher after disconnecting the power supply. Do not use any liquids such as water to extinguish the fire.
- Do not install or handle modules under wet, rainy, snowy or windy conditions. Properly place disassembled PV modules.
- Before installation, ensure that modules, especially their electrical contacts, are clean and dry. Prolonged exposure to damp conditions can cause corrosion on connector cables, rendering the module unsuitable for use.
- Do not loosen, unscrew or peel the PV module bolts and frame glue. This may lead to a reduction of the module's load rating and potential damage if the module is dropped.
- Do not drop PV modules or allow objects to fall down on the modules.
- During installation or when exposed to sunlight, do not directly touch the junction box, connector, cable, or any other electrified parts of the module without protection, regardless of whether the PV module is connected to the system. This action poses a risk of scalding or electric shock.
- Dispose of modules responsibly; they require special recycling procedures. Avoid discarding them indiscriminately.

2.4. Package Indicator Instructions

Read the unpacking instructions and the outer indicators carefully before operation. Adhere closely to the specified requirements outlined in the indicators to ensure proper handling and use.

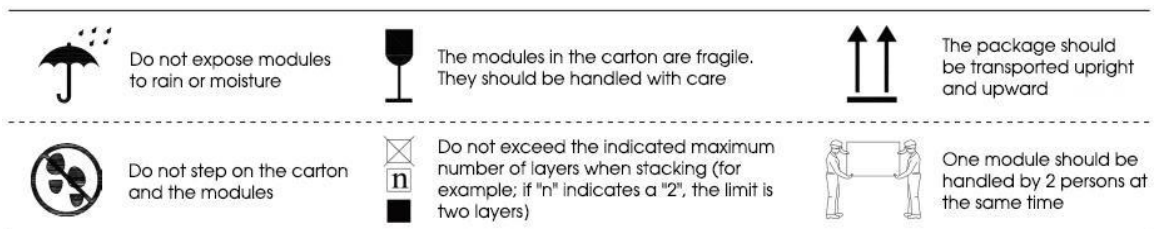


Figure: Example package indicators

3. UNLOADING/TRANSPORTATION/STORAGE

3.1. Precautions and General Safety Rules

- Under no circumstances should horizontally-oriented (landscape) packages (Figure, left) be stacked beyond two layers; stacking is not allowed under any circumstances for vertically-oriented (portrait) packages (Figure, middle). Refer to the examples provided in the figure below for correct examples of stacking (Figure, right). Adherence to these stacking guidelines is crucial to prevent potential damage or compromise to the packaged modules.



Figure: Correct stacking of packages

- Under no circumstances is tilted placement permitted.
- Forklifts are the designated transport means for modules placed on pallets. Maintain a sufficient safety distance during forklift operation. Do not stand or pass by both sides of the forklift.
- Exercise caution in controlling the speed of the forklift and mechanical arms and extensions. This precaution is essential to prevent modules from toppling over during sharp turns or sudden stops, minimizing the risk of damage to products or potential harm to individuals.

3.2. Unloading

Upon arrival at the project site, it is essential to halt the truck and initiate the unloading process in a flat and open area. Subsequently, carefully examine the outer packaging to confirm it is in good condition. Additionally, verify whether the module type and quantity stated on the outer package align with the details specified in the delivery note. This diligent check ensures accuracy and helps identify any discrepancies or damage that may have occurred during transportation.

Unloading by Forklift

- When using a forklift, pick one that can handle the weight of the goods. Make sure to use the right fork size, and insert them into the pallet adequately (generally the depth of forks into the pallet shall not be less than three-quarters of the pallet length).
Unload the modules from the truck and place them on a flat surface.

- The loading and unloading platform for the forklift should be aligned with the bottom of the forklift carriage. When retrieving items from the container, take care not to collide the forklift with the goods inside. To prevent damage to both the packages and their contents, avoid lifting the package excessively high, ensuring it does not hit the top of the carriage or the door frame.
- If the packing box blocks the driver's line of sight during loading and transportation with the forklift, it is recommended to have someone supervise and guide the process to help prevent collisions that could harm the products or cause personal injury.

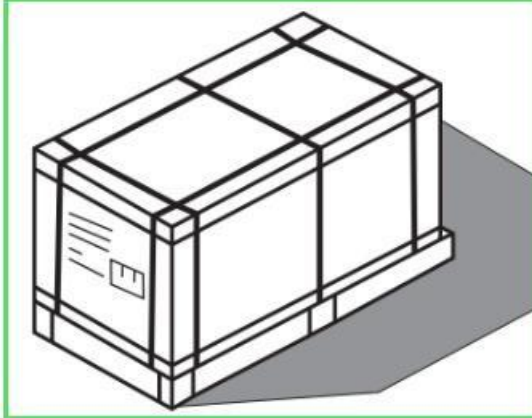
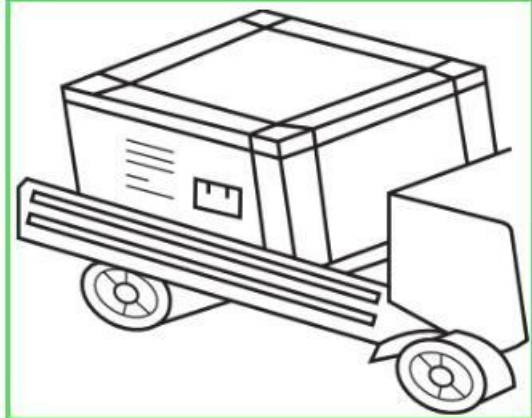
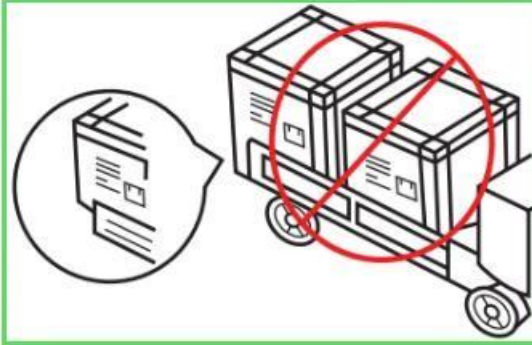
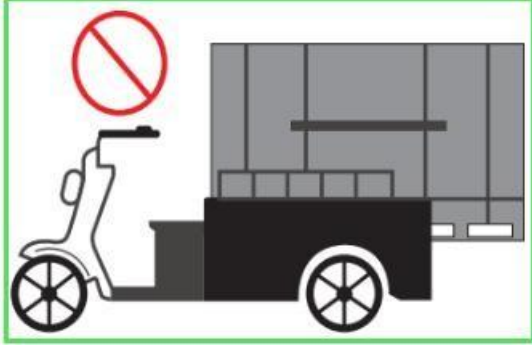
Unloading by Crane

- When using a crane to unload modules, select specialized tools based on the module's weight and size. Before lifting, carefully inspect the pallet and carton for damage. Ensure that the hoisting ropes are strong and firm. Adjust the sling position to stabilize the modules during lifting.
- For module safety, use wooden sticks, boards, or similar fixtures on the upper part of the box to prevent the sling from squeezing the pallet and damaging the modules. When placing modules, avoid lowering the packing box too rapidly. Two people should gently support the carton on both sides to place it on a flat surface.
- For horizontally-oriented (landscape) packages, refrain from lifting more than FOUR pallets of modules simultaneously; for vertically-oriented (portrait) packages, limit the lifting to no more than TWO pallets of modules at a time. Avoid unloading modules in weather conditions with wind exceeding 6 on the Beaufort scale, heavy rain, or heavy snow.



3.3. Secondary Transport

- Products in original packaging can be moved by land, sea, or air. Regardless of the way you transport them, make sure to secure the boxes on the transport platform to prevent tipping or shifting. If it is raining or snowing, try not to transport modules, but if you have to, cover the packaging completely with a rain cover.
- If you are using a pickup for transportation, only put a single layer of packages, no matter how they are wrapped. Use multiple safety ropes or straps to secure the packages around the vehicle, and put cushioning materials between the safety ropes or straps and the package to avoid direct contact that might damage the packaging. Drivers should be careful about road conditions and drive at a safe speed.
- Do not let the packaging pallets extend beyond the loading area of the transportation vehicles.
- At the project site, do not use small transport vehicles like platform trolleys to move or handle modules. Do not stack them, and only transport one layer at a time.

	
<p>YES: Secondary transport in original packaging</p>	<p>YES: Single-layer stacking</p>
	
<p>NO: Lack of ropes to secure the packages</p>	<p>NO: Use of trolleys, tricycles, or other small transport vehicles</p>

3.4. Unpacking

- When unpacking outdoors, avoid doing so in the rain as the carton can become soft and damaged when wet, potentially leading to stacked PV modules tipping over, causing damage or injury.
- In windy conditions, prioritize safety. It is not recommended to transport or unpack the modules in high wind conditions. If modules are unpacked, secure them to prevent any unintended movement.
- The work surface must be level to ensure that the package can be placed stably, avoiding sliding.
- Ensure the work surface is level to prevent sliding.
- Wear protective gloves during unpacking to prevent hand injuries and fingerprints on the glass surface.



- If not all modules are used immediately after unpacking, place the remaining ones horizontally and repackage them to help prevent tipping. When repackaging, note that the glass side of the bottom module should face up, the glass side of the middle modules should face down, and the glass side of the top module should face up. Stacks should not exceed 16 modules, and frames should be aligned.
- If unpacked modules will not be installed right away, secure them to the stand supporter with a safety rope if wind conditions are or could reach 6 or higher on the Beaufort scale (the modules should be less than 12 pieces).

3.5. Storage

- For modules requiring long-distance transport or extended storage, do not remove the original packaging and ensure the wrap film and carton box remain in good condition.
- For long-term storage, it is recommended to keep modules in a standard warehouse, conduct regular inspections, and promptly reinforce the package if any issues are detected, ensuring personal safety.
- Storage in project site warehouse or normal warehouse should maintain a moisture < 85%RH and temperature in the range from -40°C to $+50^{\circ}\text{C}$. Do not stack different types of PV modules together.
- Do not expose the modules to rain or moisture. Store finished products in a well ventilated, waterproof, dry and flat place (ensuring a ground inclination of less than 4° for vertically-oriented [portrait] packages to prevent damage or tipping). The modules should be stored in a centralized location with pallet spacing within 10cm. Cover the modules with waterproof material.
- When storing modules at the project site, avoid soft or easily collapsible ground. Choose a hard or elevated surface to prevent long-term storage-related collapse or tilting of module packages.
- The module must be installed as soon as possible at the project site and must not be exposed to rain or damp conditions during storage. Uninstalled modules should not be exposed to rain or damp conditions because the wire connectors should not get wet. Once connected, they are suited for exposure to the elements. IMPERIAL STAR SOLAR will not be responsible for any damage or collapse of the modules caused by moisture in the packaging.

4. LOCATION AND ANGLE

4.1. Installation Environment

- For optimal performance and in most circumstances, it is important to install PV modules in areas that receive maximum sunlight throughout the year. In the Northern Hemisphere, the PV modules should typically face south, and in the Southern Hemisphere, the PV modules should typically face north.
- When selecting the installation location, avoid areas with trees, buildings, or obstacles. These objects can cast shadows on the solar PV modules, especially when the sun is at the lowest position on the horizon in winter. Shadows can lead to a decrease in the output power of the solar system. While the bypass diode installed in the PV module can help reduce this loss somewhat, it is crucial not to ignore the shadow factor.
- Do not install solar PV modules near fire or flammable materials. Do not install solar PV modules in areas prone to water exposure, such as places with soaking water, sprinklers, or water spray.
- For rooftop installations, make sure the roof can handle the load. Design the construction plan thoughtfully, leaving a safe working area between the roof's edge and the outer edge of the PV module array.
- The straight-line distance between the installation site and the coastline shall be not less than 50m unless otherwise agreed in a written form by Imperial or stated in the contract.
- If installing near the coastline, maintain a minimum straight-line distance of 50 meters unless otherwise agreed in written form by Imperial Star Solar or such a matter is specified in the contract.

4.2. Tilt Angle of Installation

- When setting up solar panels, it is crucial to place them all facing the same direction and at the same angle. If they are not aligned, the electricity (current and voltage) they produce may not match up due to differences in how they absorb sunlight. This mismatch can result in a loss of power output for the entire PV system.
- For the best power generation, it is ideal to have the solar panels directly facing the sun. If you are using fixed brackets, it is important to choose an angle that ensures the panels generate the most power, especially during the winter. This way, you will have sufficient power output throughout the entire year.
- To maximize energy output, it is recommended to install solar panels at an optimized tilt angle. You can find detailed information on the best angle in standard solar installation guides or by consulting a reputable solar expert. Keep in mind that dust on the panels can reduce performance. IMPERIAL STAR SOLAR suggests installing panels at a tilt angle of at least 10° to make it easier for rain to wash away dust. If the angle is less than 10 degrees, any resulting issues will not be covered by the manufacturer's warranty.

- As a general guideline, the tilt angle can be roughly equal to the latitude of your location, facing towards the equator. However, it is essential to consider other local requirements for an optimized system design. Installation inclination refers to the angle between the module and the ground plane, as shown in the figure below.

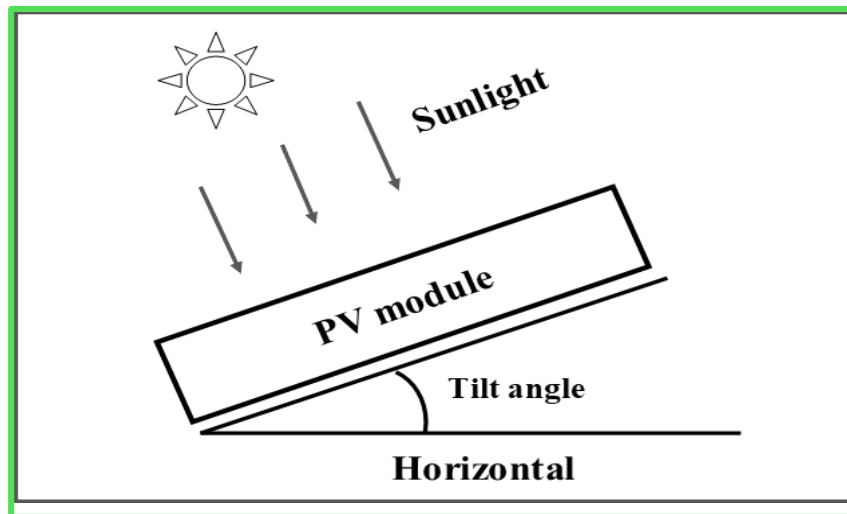


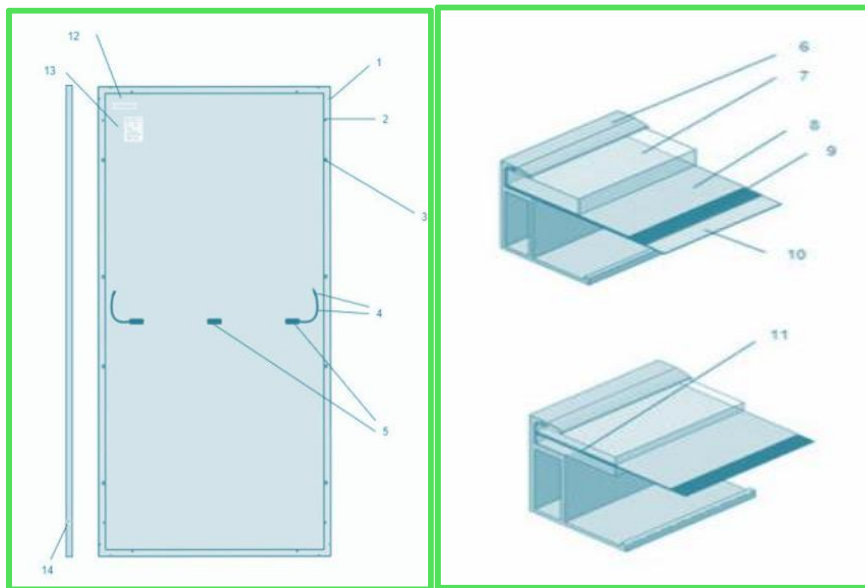
Figure: Installation inclination (angle)

4.3. Identification Labels on PV Modules

IMPERIAL STAR SOLAR offers two main types of PV modules: single glass modules and dual glass modules. These modules carry important identification labels to provide essential information in addition to the electrical and mechanical diagrams (see Figure for example). The contents of these labels are described below:

- **Nameplate:** This label, typically affixed to the back of the module, contains crucial details about the product. It includes the product type, rated power (P_{max}), rated voltage (U_{mp}), rated current (I_{mp}), open circuit voltage (V_{oc}), short circuit current (I_{sc}), certification mark, maximum system voltage, and other relevant information. These specifications are measured under standard test conditions.
- **Current Classification Label:** The module is categorized based on its rated current, and this classification is clearly marked on the module. This label helps distinguish modules with different current ratings.
- **Serial Number Bar-code:** Each module has a unique serial number printed on top of the bar-code label. This serial number serves as the module's identification mark and is associated with all production information. The serial number is located in the non-cell area inside the module, visible from the front side, and is designed to be indestructible. An identical serial number is also found on the outer back side of the module.

These identification labels play a crucial role in providing users and installers with essential information about the PV modules, ensuring proper installation and maintenance.



1	Drain hole	8	EV A
2	Grounding hole	9	Cell
3	Mounting hole	10	Encapsulated back sheets
4	Wire/ Connector	11	EVA/POE
5	Split junction box	12	Bar code
6	Aluminum alloy frame	13	Nameplate
7	Glass	14	Bar code

Figure: Example mechanical diagram of module structure

5. MECHANICAL INSTALLATION

5.1. Installation Guidelines

PV modules can be installed using either the bolt method or the clamp method. It is essential to follow the examples and recommendations provided below. If you wish to use a different installation method, please contact IMPERIAL STAR SOLAR customer service or the technical support team for guidance and approval. Improper installation may lead to module damage, and using an unapproved mounting method will void the warranty.

Load Conditions and Mounting Design

- Do not subject modules to wind or snow loads beyond the designed limits.
- Do not subject modules to excessive forces, thermal expansion of support structures, and similar situations.
- Professional engineers must select and design the mounting bracket after calculating loads based on climatic conditions at the installation site.
- The installation method and supporting system must be strong enough to withstand all load conditions, and the installer is responsible for providing this guarantee.
- The support systems must be tested by the third-party organization capable of performing static mechanical testing and in accordance with the required local, national, and international standards.

Continuous Rails

- Modules must be mounted on continuous rails extending beneath the modules. Mounting without continuous rails reduces the allowable load, requiring re-evaluation by IMPERIAL STAR SOLAR.

Color Matching

- Ensure that the modules with the same color cells are installed together.

Clearance

- Maintain a recommended clearance of at least 115 millimeters between modules and walls or roof surfaces.
- Minimum clearance between two adjacent single cell modules must not be less than 10 millimeters. Minimum clearance between two adjacent bi-facial cell modules must not be less than 20 millimeters. Proper gapping helps protect against jarring with neighboring modules due to the expansion and contraction of modules; it also can reduce the wind pressure on the square array. If there are special requirements, please confirm with IMPERIAL STAR SOLAR prior to installation.

Drain Holes and Handling

- Ensure module frame drain holes remain unobstructed at all times (including during installation and use).

- Avoid contact between the back of the PV module and foreign bodies or support components to prevent damage.

Temperature Considerations

- Module frames may warp at low temperatures. Avoid lateral tension and pressure on the frame that may cause the frame to come apart or breakage on the glass surface.
- Prevent direct contact of dissimilar metals with the aluminum frame to avoid galvanic corrosion. Refer to IEC 60950-1 standards recommending metal combinations not exceed an electrochemical potential difference of 0.6V.

Corrosion Resistance

- IMPERIAL STAR SOLAR recommends the use of corrosion-proof (stainless steel) attachment hardware for maximum mounting longevity.

Installation Steps

- Secure the module in each mounting location with an M8 bolt (full thread recommended) and a flat washer, spring washer, and nut and tighten to a torque of 16~20Nm. The yield strength of bolt and nut should not be less than 450 MPa. The tightening steps are as follows:
 - ① Use torque wrench to tighten the nut to target torque: 16~20Nm;
 - ② Loosen the nut 90~180 degrees;
 - ③ Tighten the nut to the target torque and reduce the torque attenuation.
- All parts in contact with the modules should use flat stainless steel washers of minimum 1.5 millimeter thickness with an outer diameter of 16-20mm, except for single-axis tracking systems (see section 5.4 Installation of Single-axis Tracking System).
- The listed installation methods are for reference only. Trained professionals should handle PV system design, mechanical load calculation, installation, maintenance, and safety. IMPERIAL STAR SOLAR does not supply materials for system installation.

Required Tools

- Required tools include a screwdriver, wrench, stainless steel screws/bolts, clamps, nuts, spring washers, and plain washers.

5.2. Clamp Mounting

Installation precautions

It is essential to follow the examples and recommendations provided below. If you wish to use a different installation method, please contact IMPERIAL STAR SOLAR customer service or the technical support team for guidance and approval. Improper installation may lead to module damage, and using an unapproved mounting method will void the warranty.

IMPERIAL STAR SOLAR has conducted tests on modules using various clamps from different manufacturers. It is advised to use fixing bolts of at least M8. For optimal results, consider the following guidelines:

Clamp Specifications

- Use fixing bolts of at least M8.
- Recommended clamp specifications: Length \geq 60mm; thickness \geq 4mm; made of aluminum alloy 6005-T6.
- The clamp should withstand loading without malfunctioning due to deformation or corrosion. Any deviation in size requires evaluation and approval from IMPERIAL STAR SOLAR.

Overlap and Quantity

- Ensure the clamp overlaps the module frame by at least 7 millimeters but no more than 10 millimeters.
- Use a minimum of four clamps to secure modules to the mounting rails.

Contact and Deformation

- Clamps should not come into contact with the front glass and must not deform the module frame.
- The clamps should not extend out the edge of the module under any circumstances. Be sure to avoid shadowing effects on the solar cells from the module clamps.

Frame Modification and Installation Method

- Under no circumstances should the module frame be modified.
- For clamp-mounting, use a minimum of four clamps per module, with two clamps on each long side for horizontally-oriented (landscape) modules.
- Depending on local wind and snow loads, additional clamps may be required to ensure that modules can bear the load.

Applied Torque

- Applied torque must adhere to the mechanical design standard of the respective bolt being used by the customer. For example, if the customer is using an M8 bolt, the applied torque should fall within the range of 16-20Nm.

Clamp Positions

- Clamp positions are of crucial importance for the reliability of the installation. The clamp center-lines must only be positioned within the ranges indicated in table below, depending on the configurations and loads.

For any deviation from these recommendations or the use of different clamp sizes, it is essential to consult with IMPERIAL STAR SOLAR for evaluation and approval to ensure any warranties remain valid.

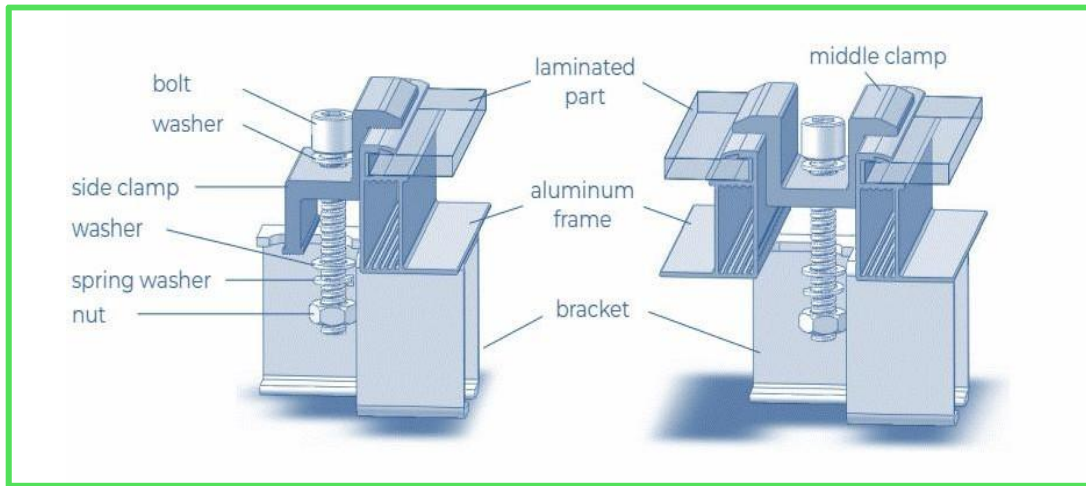


Figure: Example clamp

Installation process

<p>Step 1: Bracket mounting</p> <p>Mount the rail bracket</p>		
<p>Step 2: Clamp mounting</p> <p>Fix the clamp on the bracket and leave the nut untightened</p>		
<p>Step 3: Module Mounting</p> <p>Put the module into the clamp at the required</p>		

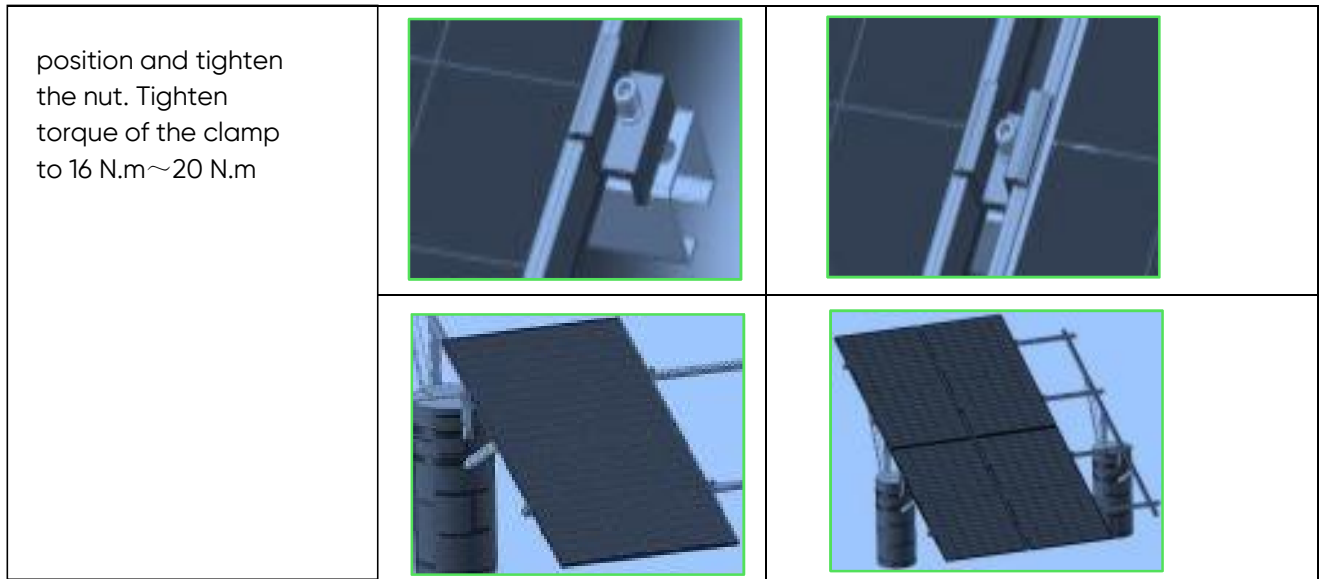


Table: Maximum test loads

Module	Test Load	Mounting Direction
Length≤2400mm	<p>Negative load (back/wind): ≤2400Pa</p> <p>Positive load (front/snow): ≤5400Pa</p>	<p style="text-align: center;">$1/6L \leq A \leq 1/4L$; L=Module length</p> <p>*NOTE:</p> <ol style="list-style-type: none"> 1. The crossbeam is perpendicular to the long side. 2. The above described distance is from the module edge to the middle of the clamp. Clamps length ≥60mm. 3. Requires two support rails below the PV module to ensure the mechanical load. 4. This installation may cause the cell to be covered. This method is not recommended for framed bifacial double-glass.
Length≤2000mm	<p>Negative load (back/wind): ≤2400Pa</p> <p>Positive load (front/snow): ≤3600Pa</p>	<p style="text-align: center;">$1/6L \leq A \leq 1/4L$; C=10±2mm; L=Module length</p> <p>*NOTE:</p> <ol style="list-style-type: none"> 1. The beam is parallel to the long side. 2. The above-described distance is from the module edge to the middle of the clamp. Clamps length ≥60mm. 3. Requires two support rails below the PV module to ensure the mechanical load. 4. The brackets run parallel to the long sides of the PV modules and
2000<Length ≤2400mm	<p>Negative load (back/wind): ≤2400Pa</p> <p>Positive load (front/snow): ≤2400Pa</p>	<p>*NOTE:</p> <ol style="list-style-type: none"> 1. The beam is parallel to the long side. 2. The above-described distance is from the module edge to the middle of the clamp. Clamps length ≥60mm. 3. Requires two support rails below the PV module to ensure the mechanical load. 4. The brackets run parallel to the long sides of the PV modules and

		<p>will not cause obstruction. This method is recommended for framed bifacial double-glass.</p> <p>5. The load capacity is an empirical value specific to a standard module under standard installation conditions. For precise details, it is recommended to consult IMPERIAL STAR SOLAR for the specific information relevant to your installation.</p>
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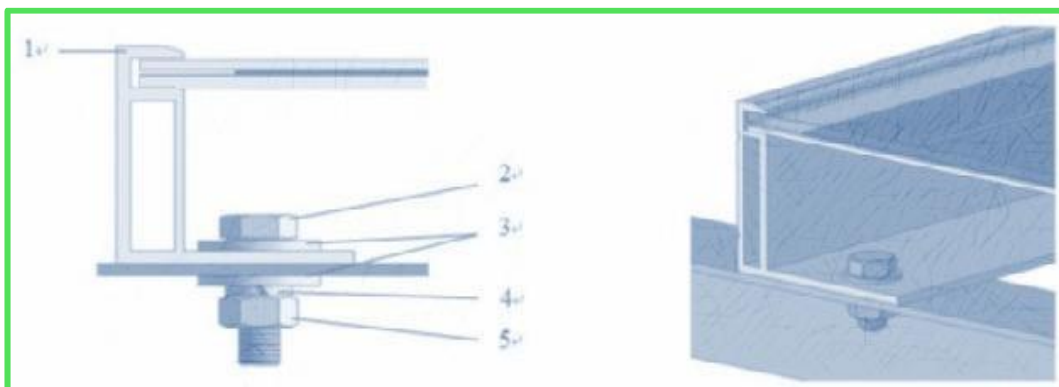
5.3. Bolt Mounting

This section explains how to bolt mount modules using the mounting holes, ensuring optimal stability and load handling capability.

Installation precautions

- The frame of each module has eight mounting holes measuring $\phi 9*14$ millimeters that are placed to optimize the load handling capability. Use these holes to secure the modules to the supporting structure. The outer four holes should be used first, as illustrated in the figures under the heading "Maximum Test Loads". It is recommended to mount the PV module vertically using bolts. This configuration enhances stability, minimizing the risk of sliding and ensuring safer use.
- Secure the modules to the support rails using bolts through the four mounting holes measuring $\phi 9*14$ millimeters on the back of the module frame. Refer to the provided figures for specific mounting details.
- The yield strength of bolts and nuts should be a minimum of 450 MPa.
- For M8 bolts, the recommended tightening torque is 14~20Nm.
- For M6 bolts, the recommended tightening torque is 8~14Nm.
- Use washers with an outer size between 20~22 millimeters and a thickness not less than 2 millimeters.

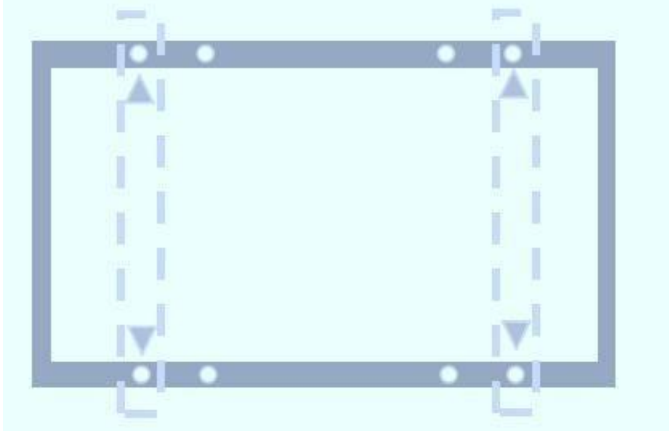
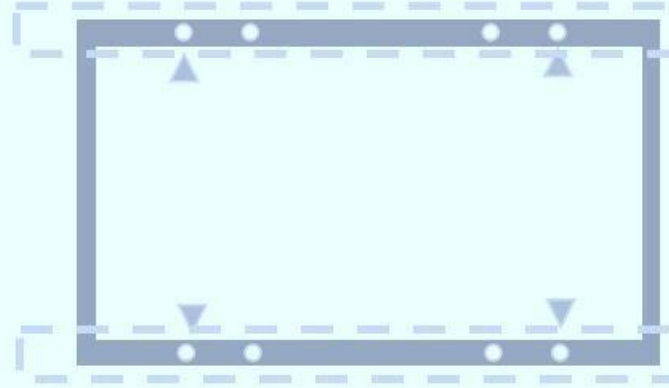
These guidelines ensure the secure and efficient attachment of modules to the supporting structure. Adhering to the specified torque and washer dimensions is crucial for maintaining the structural integrity of the installation.



1	Aluminum frame	4	Stainless steel spring washer
2	M8 hex bolt	5	Stainless steel hex nut
3	Flat stainless steel washer		

Figure: Bolt mounting

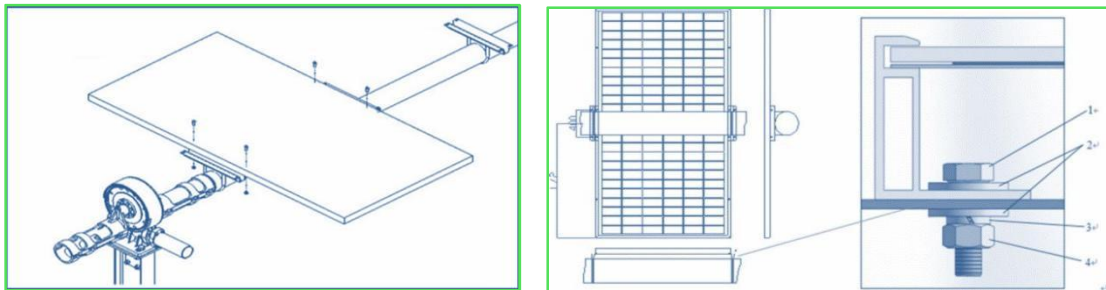
Maximum test loads

Module	Test Load	Mounting Direction
Length ≤ 2400mm	<p>Negative load (back/wind): ≤ 2400Pa</p> <p>Positive load (front/snow): ≤ 5400Pa</p>	 <p>*NOTE:</p> <ol style="list-style-type: none"> 1. The crossbeam is perpendicular to the long side. 2. Requires two support rails below the PV module to ensure the mechanical load. 3. The load capacity is an empirical value specific to a standard module under standard installation conditions. For precise details, it is recommended to consult IMPERIAL STAR SOLAR for the specific information relevant to your installation.
Length ≤ 2400mm	<p>Negative load (back/wind): ≤ 2400Pa</p> <p>Positive load (front/snow): ≤ 2400Pa</p>	 <p>*NOTE:</p> <ol style="list-style-type: none"> 1. The beam is parallel to the long side. 2. Requires two support rails below the PV module to ensure the mechanical load. 3. The load capacity is an empirical value specific to a standard module under standard installation conditions. For precise details, it is recommended to consult IMPERIAL STAR SOLAR for the specific information relevant to your installation.

5.4. Installation of Single-axis Tracking System

Installation precautions

- Attach modules using the four mounting holes measuring $\phi 7*10$ millimeters on the back of the module frame that are placed to optimize the load handling capability. Secure the module to support rails with bolts. The mounting details are shown in the following figures.
- IMPERIAL STAR SOLAR recommends the use of corrosion-proof (stainless steel) attachment hardware for maximum mounting longevity.
- Secure each module with an M6 bolt (full thread recommended), along with a flat washer, spring washer, and nut, tightening to a torque of 16~20Nm. It is essential to use stainless steel or other anti-corrosion material for the bolts.
- Ensure reliability by incorporating flat stainless-steel gaskets with a minimum thickness of 1.5 millimeters and an external diameter of 16-20 millimeters in all components connected to the Single-axis tracking system.
- The mechanical load pressure under this method should not exceed 30lbs/ft² from both the front and rear sides, following UL1703 guidelines.



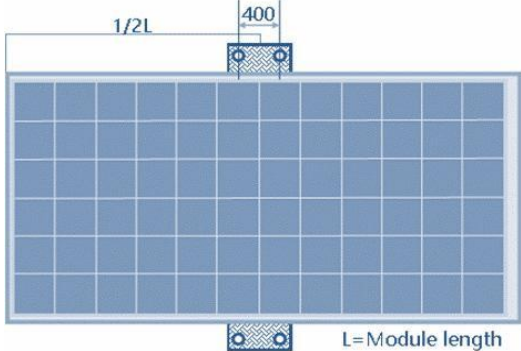
1	M6 Stainless steel hex bolt	3	Stainless steel spring washer
2	Flat stainless steel washer	4	Stainless steel hex nut

Figure: Single-axis system mounting

Installation Process

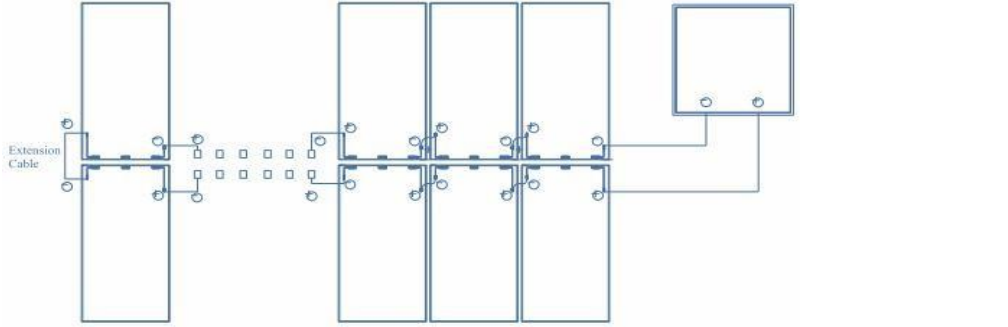
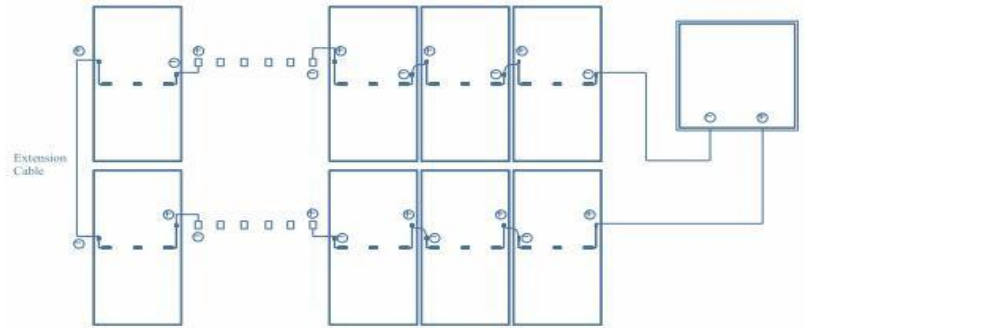
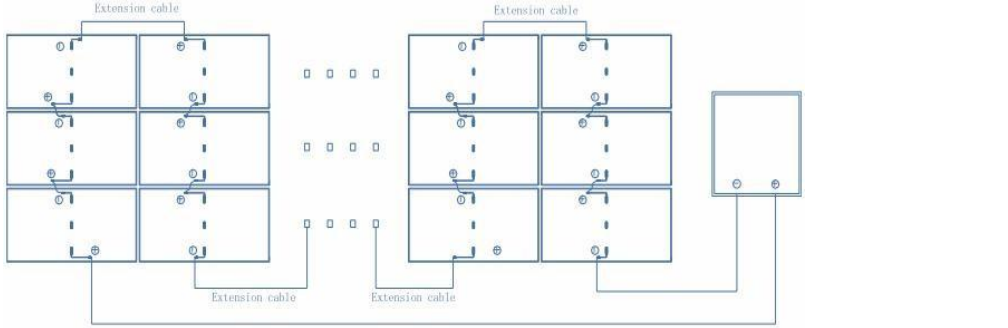
- The modules can be installed horizontally (landscape) or vertically (portrait). Refer to clamp mounting for the bolt mounting process. After setting the bracket and placing the module on top of it, put the bolts in the mounting holes and tighten them after the module is adjusted.

Maximum test loads

Module	Test Load	Mounting Direction
<p>Length ≤ 2000mm</p>	<p>Negative load (back/wind): ≤ 1600Pa</p> <p>Positive load (front/snow): ≤ 1600Pa</p>	
<p>2000mm < Length ≤ 2400mm</p>	<p>Negative load (back/wind): ≤ 1200Pa</p> <p>Positive load (front/snow): ≤ 1200Pa</p>	<p>*NOTE:</p> <ol style="list-style-type: none"> 1. The above-described distance is from the middle of the bolts to the middle of the bolts. 2. The load capacity is an empirical value specific to a standard module under standard installation conditions. For precise details, it is recommended to consult IMPERIAL STAR SOLAR for the specific information relevant to your installation

6. ELECTRICAL INSTALLATION

6.1. Cable Layout

Description	Example Diagram
Split junction box mounted at the side of a vertically-oriented module	
Split junction box mounted at the middle of a vertically-oriented module	
Split junction box mounted at the middle of a horizontally-oriented module	

Precautions:

1. When setting up modules with a split J-Box, use the recommended vertical (portrait) installation methods with an extension cable (required).
2. To reduce the risk of damage during indirect lightning strikes, avoid creating loops in your system design. Also, to ensure safety and product longevity, do not apply more than 60N of force when installing, dismantling, maintaining, or handling the cable, connector, and split junction box.
3. When installing modules, connect them in the same direction as the wire to prevent bending.

6.2. Electrical Connection

- The Direct Current (DC) generated by the PV system can be converted to Alternating Current (AC) and connected to the public power grid. Different regions may have different policies, laws and regulations stipulating the installation and grid-connection requirements of PV systems. Ensure compliance for your site.
- PV modules can obtain different current and voltage outputs through series and parallel connection. Read this installation manual carefully before electrical

connection and installation. Design and connect according to the current and voltage required for your site. Before connection, ensure that the connections are free from corrosion, and keep the connections clean and dry.

- Different module types should not be linked in series. In instances where modules are connected in series, it is essential to maintain uniformity in their current (for modules with different current classes, it is permissible to install those with adjacent current classes within a single string). It is crucial to ensure that the cumulative voltage of the module string does not surpass the specified system voltage, as indicated on the nameplate or datasheet of the module.
- The copper cables used in IMPERIAL STAR SOLAR modules are designed to resist UV damage and have a cross-sectional area of at least 4 mm² (equivalent to 12 AWG). Any other cables used for connecting the DC system should meet the same or higher specifications.
- The maximum number of modules in series depends on the system design, converter type, and environmental conditions. Generally, you can calculate the maximum number (N) of PV modules in series by dividing the maximum system voltage by the open circuit voltage of the solar PV modules. Consider the temperature-related voltage change when designing the system, especially in extreme winter conditions. You can calculate the maximum number of series connections of solar PV modules using the following formula (reference only).

Formula	Maximum system voltage $V \geq N \cdot V_{oc} \cdot [1 + \beta \cdot (T_{min} - 25)]$
V	Maximum system voltage
N	Maximum number of solar PV modules connected in series
V_{oc}	The open circuit voltage of each module (see product label or datasheet)
β	Temperature coefficient of open circuit voltage of the module (refer to datasheet)
T_{min}	The lowest ambient temperature at installation site

Table: Formula for calculating maximum number of connections

- The number of modules that can be connected should be determined by a qualified institution or professional individual in accordance with the design specifications of the photovoltaic system and the local electrical design standards. The calculation formula provided by IMPERIAL STAR SOLAR is for reference purposes only.
- If the modules are allowed to be installed in parallel, each module (or series string of modules so connected) shall be provided with the maximum series fuse as specified. For applications requiring high currents, several photovoltaic modules can be connected in parallel; the total current is equal to the sum of individual currents, and each module (or series string of modules so connected) shall be provided with the maximum series fuse as specified. It is recommended to connect only one module in parallel. When connected in series, all modules must have the same amperage, and when connected in parallel, the modules must all have the same voltage. Connect the number of modules that match the voltage specifications of the devices used in the system. Avoid connecting modules together to create a voltage higher than the permitted system voltage.
- Irreparable damage to products can occur if an array string is connected with reverse polarity to another. Before making a parallel connection, always check the voltage

and polarity of each individual string. If you find reversed polarity or a difference of more than 10V between strings during measurement, verify the string configuration before making the connection.

- Before wiring the module, ensure that the contact points are corrosion resistant, clean, and dry; If a string of modules is reversed, irreparable damage can be caused.
- During field wiring, use only single-wire photovoltaic special copper cables with a minimum temperature resistance of 90 °C, sunlight resistance (UV), and a cross-sectional area of at least 4mm² as photovoltaic connecting wires. The cable should have a minimum and maximum outer diameter of 5 millimeters to 7mm, respectively. The minimum bending radius must be 43 millimeters. Please note that any cable damage caused by excessive bending or the cable management system is not covered under IMPERIAL STAR SOLAR's warranty.
- When installing modules on a roof, it is recommended to use a 4~6mm² special photovoltaic cable. Plug & Play connectors are included at the end of each cable. All other cables used to connect the direct current system should have similar (or higher) specifications and the appropriate insulation to withstand the possible maximum system Voc (as defined in TUV 2PFG1169 or EN50618 (H1Z2Z2-K)) or 62930 IEC 131 1x4mm². IMPERIAL STAR SOLAR requires all cables and electrical connections to comply with the electrical regulations of the countries where the PV system is installed to maintain a valid warranty.
- Under typical conditions, a PV module is expected to encounter situations that result in higher current and/or voltage compared to the values reported at standard test conditions. Therefore, when determining component voltage ratings, conductor current ratings, and the size of controls (such as inverters) connected to the PV output, it is recommended to multiply the values of Isc and Voc marked on this PV module by a factor of at least 1.25. This ensures a more accurate assessment of the system's requirements under real-world operating conditions.
- When choosing a cable, you can calculate the minimum current-carrying capacity using the following formula (reference only):

Minimum current-carrying capacity of the cable=1.25×Isc×Np; where:

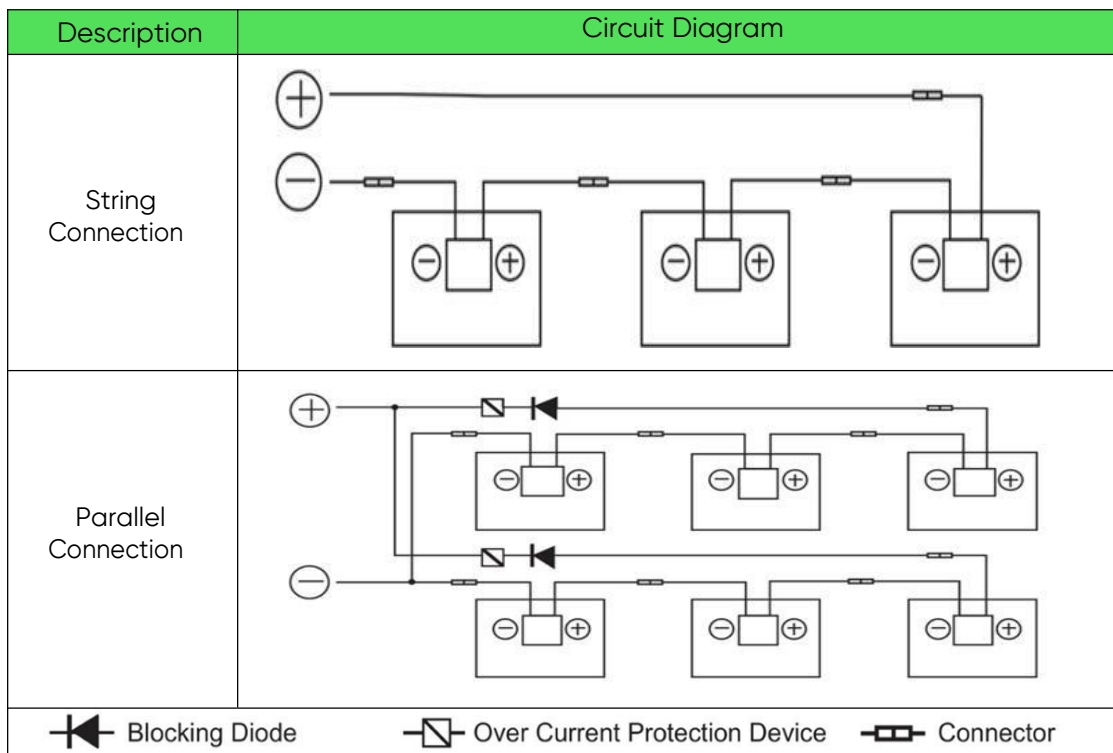
Isc is the short-circuit current of the PV module (unit: A).

Np is the number of modules in parallel or module strings.

- To ensure the proper operation of the system, it is crucial to observe the correct cable connection polarity when linking modules to each other or to a load, such as an inverter or a battery. Incorrect connections may lead to the destruction of bypass diodes. Therefore, careful attention to the correct polarity during module connections is essential for system integrity.
- Before connecting the module, ensure the use of connectors approved by IMPERIAL STAR SOLAR. IMPERIAL STAR SOLAR is not responsible for any potential defects or risks if unauthorized connectors are used. When conducting electrical connections for the modules, use diagonal pliers to cut the cable tie. Be cautious not to scratch the cables or the backside of the module during this process. Follow the electrical requirements by connecting the positive and negative connectors in sequence. Confirm you hear a "click" sound to ensure a successful connection. Poor connections

may lead to electric arcs during module operation, causing potential burns to the connectors. Avoid interconnecting different types of connectors. Note that the unlock method for connectors may vary according to local laws and regulations; pay attention to these differences.

- When modules are connected in series, the string voltage is the sum of every individual module in one string. When modules are connected in parallel, the current is the sum of the individual modules as shown in the following figure. Modules with different electric performance models cannot be connected in one string. In the absence of adequate protection through anti-reverse devices and fuses for the string, refrain from linking two or more strings using Y or T connectors. Do not connect fuses in the combiner box or string inverter with two or more strings in parallel without using an anti-reverse device or function.



- Before commissioning and operating the power station, it is crucial to check the electrical connection of modules and strings. Ensure that all connection polarities are correct, and the open circuit voltage meets the acceptance criteria.
- The design of the number of modules in series and in parallel should be done reasonably based on the system configuration.
- To manage excess cables, it is recommended to clear or trim them. IMPERIAL STAR SOLAR advises keeping all cables away from standing water and placing them in proper pipework to avoid accelerated aging due to UV irradiation.
- Additionally, IMPERIAL STAR SOLAR recommends the use of lightning protection devices that comply with local laws and electrical regulations. This is to enhance the safety and performance of the power station.

It is important to adhere to all the instructions mentioned above to meet the warranty conditions provided by IMPERIAL STAR SOLAR. Following these guidelines ensures proper installation, operation, and maintenance of the solar power system, which is essential for preserving the warranty coverage. If there are any uncertainties or questions regarding the instructions, it is advisable to seek clarification from IMPERIAL STAR SOLAR or consult with a qualified professional to guarantee compliance with the warranty conditions.

6.3. Bypass Secondary

- If a shadow obstructs part of a PV module, it can result in reverse voltage across the solar cells. This may cause current to flow through unaffected sections, impacting other modules or strings and leading to power loss and increased heat in the affected cells. To mitigate this, when a PV module is connected in parallel with a bypass diode, the current in the system flows through the diode, bypassing the shaded part of the module. This minimizes heating and power consumption. It is important to note that bypass diodes are not designed as overcurrent protective devices.
- Each module typically has three diodes. It is crucial not to attempt to open the junction box to replace the diode. Even if there is an issue with the diode, it is recommended to have professionals handle this task.
- Be careful to protect against inductive lighting, backflow, and incorrect connections to ensure the proper functioning and safety of the PV system.

6.4. Grounding

- All module frames and mounting racks must be correctly grounded according to the electrical design, construction specifications, procedures, and regulations applicable to the installation sites, including any special grounding requirements.
- Proper grounding can be achieved by connecting the module frame(s) and all metallic structural components together by using a suitable grounding conductor. The grounding conductors or wires may be copper, alloy, or any other materials that comply with the local electrical design and construction specifications, procedures, and regulations. It is recommended to use copper wire (4-14mm² or AWG 6-12) as the grounding wire. The symbol "⏏" can be found at the grounding hole position. The ground wire must also be connected to ground through a suitable ground electrode (see the figure below). Ensure a tight connection of all the joint points.

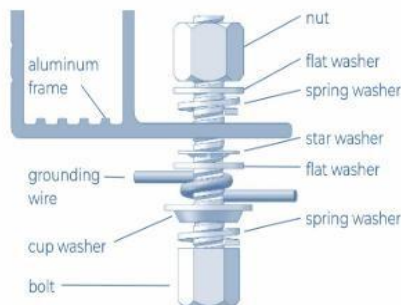


Figure: Grounding hole installation

- On a grounding hole with a diameter of $\phi 4$ millimeters, use a separate grounding wire and any required accessories to connect the aluminum frame of the solar PV module. Connect the grounding wire to the ground. The grounding uses the M4*12mm bolts and M4 nuts, star washers and plain washers, this ensures that the modules are firmly grounded (see figure below). You can find the corresponding product drawing in the module datasheet to verify the detailed number, size, and position of the grounding holes. The torque applied to ground point is $4\text{N}\cdot\text{m} \sim 8\text{N}\cdot\text{m}$. Do not drill any extra ground holes as doing so will void the module warranty. IMPERIAL STAR SOLAR recommends using grounding wires with resistances that are less than 1Ω .

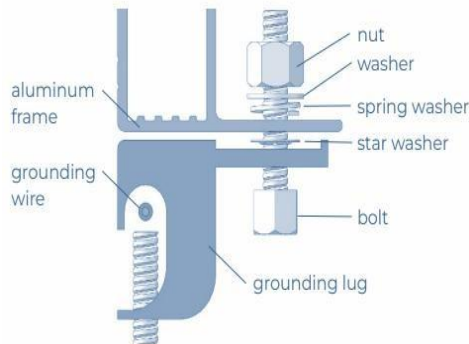


Figure: Grounding clamp installation

- If the module is grounded through mounting holes using serrated washers or nuts without any additional grounding requirements, it is essential to maintain the ground resistance of the entire racking system below 4Ω . To achieve this, it is necessary to use new serrated washers. Reusing previously used washers is not permitted, as it may compromise the effectiveness of the grounding system.
- When grounding, each module can be grounded individually, or you can opt for grounding in series or in parallel (see figure). If you choose the latter two options, it is advisable that the maximum number of modules connected in parallel should not exceed four, and in series should not exceed eight.

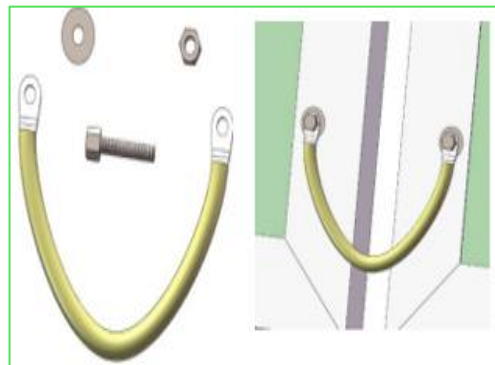


Figure: Grounding connection between modules

- In addition to using the grounding hole, you can also consider the following grounding methods:
 - ① Utilize unused mounting holes for grounding purposes.
 - ② Explore the use of specialized grounding devices designed for professional installations.

- For all the mentioned grounding methods, the electrical contact points should penetrate the anodized film of the aluminum frame. PV modules can also be grounded by other certified and reliable grounding devices. However, it is essential to adhere to the manufacturer's requirements and guidelines when using alternative grounding methods.

6.5. Safety Protocols for PV Module Disassembly and Grounding Systems

- During the disassembly of the conductor, PV modules must be entirely covered with opaque plastic or other covering to prevent electrical currents. The mounting structure material used must be compatible with the module; otherwise, any resulting corrosion and subsequent failure will void the warranty.
- The potential of the DC-side system of the PV array can be managed by floating, positive grounding, and negative grounding according to the system requirements. Different cell technologies have different adaptations. At the power station project, if the module of crystalline silicon cells generates excessive absolute value of the negative potential to ground, there is a risk of potential induced degradation (PID). Therefore, it is advisable to use the negative grounding system to ensure the positive potential of the circuit. For detailed information, consult the inverter manufacturer.

7. MAINTENANCE

In order to ensure the long-term use of the installed PV system and optimize power output performance of the modules, the installed PV modules need to be inspected and maintained regularly, which is the responsibility of the users. The inspection and maintenance of modules in the PV array shall be carried out by personnel who have received professional PV system maintenance training, possessing the necessary qualifications and authorization.

7.1. Panel Visual Inspection and Replacement

- Regularly inspecting the modules within a PV array is crucial to identify potential issues. Look for signs of damage, including glass breakage, cable breakage, junction box damage, and poorly connected terminals. These issues can lead to functional and safety problems. If a module is found to be damaged, replace it with the same type of module. Always exercise caution and avoid touching live parts of cables and connectors. When handling modules, use appropriate safety equipment such as insulated tools and insulating gloves. Refer to the relevant product installation manual for guidance on the proper installation and disassembly of modules.
- Regularly inspect the electrical, grounding, and mechanical connections of your PV system at least every six months. Ensure that all connections are clean, safe, and free from damage or rust. Check the operation of all string fuses in each non/earthed pole and verify the tightness of mounting parts. Inspect all cables and confirm the security of connectors. Ensure PV modules frames and brackets are well connected.
- Examine the surface of PV modules for any foreign objects or shielding. Regularly trim vegetation to prevent shading, ensuring optimal performance of the modules.
- When repairing PV modules, cover the surface of PV modules with opaque material to prevent electric shock. Exposure of PV modules to sunlight will generate high voltages, this is dangerous. Please pay attention to safety when maintenance and it must be done by professionals.
- For personal protection, wear cut-resistant gloves and other required personal protective equipment according to the specific installation. Isolate the affected array string to prevent current flow before attempting module removal. Use the disconnect tool provided by suppliers to safely disconnect connectors. Replace damaged modules with new functional modules of the same type.
- In systems using batteries, blocking diodes are typically installed between the battery and PV module output to prevent battery discharge at night.
- When irradiance is 200W/m² or higher, a variance in terminal voltage exceeding 5% from the rated value may indicate improper or poor connectivity between modules.
- Follow maintenance instructions for all components in the PV system, including brackets, charging rectifiers, inverters, batteries, lightning protection systems, etc.

Warning: Do not remove or discard the warning labels on the PV modules. Prior to any electrical maintenance, the PV system must be shut down. Improper maintenance of the system can pose severe dangers, including electric shock and risk of burning. Adhere to the precautions outlined earlier in this manual to ensure personnel safety and prevent potential hazards.



7.2. Connector and Cable Inspection

It is recommended to implement the following preventive maintenance every six months:

- ① Check the sealing gels of the junction box for any damage.
- ② Examine the PV module(s) for signs of deterioration. Check all wiring for possible rodent damage and weathering. Ensure that all connections are tight and corrosion free. Check electrical leakage to ground.
- ③ Inspect all cables to verify that connections are tight, the cables are protected from direct sunlight and positioned away from areas with water collection.
- ④ Check the torque of terminal bolts and the general condition of wiring. Check that mounting hardware is properly torqued to prevent loose connections that could result in damage to the array.

7.3. Cleaning

This section outlines the requirements for the cleaning procedures of IMPERIAL STAR SOLAR PV modules. Professional installers are urged to read and meticulously adhere to these guidelines. Failure to comply with these instructions may lead to death, injury, or property damage. It is essential to note that damages resulting from inappropriate cleaning procedures will void the IMPERIAL STAR SOLAR warranty.

- The power output of the module is directly affected by the amount of sunlight it receives. Accumulated dust on the glass surface of the module can diminish power output and potentially lead to hot spots. Therefore, it is crucial to keep the surface of PV modules clean. Maintenance work, including cleaning, should be performed at least once every six months or more frequently if needed. Removal of debris such as bird droppings, leaves, and dust is necessary, and proper cleaning of the module may be required to maintain optimal performance.

Warning: Cleaning of PV modules should be conducted exclusively by trained personnel. Workers engaged in these activities must wear Personal Protective Equipment (PPE) to ensure their safety. PPE requirements include goggles for eye protection, electric insulation gloves, and safety shoes. The gloves used should have the capability to withstand DC voltages of no less than 2000V.



- Improper cleaning activities pose the risk of damaging modules and array components, increasing the potential hazard of electric shock. Cracked or broken modules especially represent an electric shock hazard due to leakage currents, and

this risk is increased when modules are wet. Before cleaning, thoroughly inspect modules for cracks, damage, and loose connections.

- It is crucial to note that during daylight hours, the voltage and current in the array are sufficient to cause a fatal electric shock. Therefore, clean PV modules only when the irradiance is below 200W/m². Before starting the cleaning process, ensure that the circuit is disconnected to prevent injury from contact with exposed live parts. Wear appropriate protective clothing, including insulating gloves, during the cleaning process. Do not immerse the module, either partially or entirely, in water or any cleaning solutions. Do not use lubricants or organic solvents to clean connectors, as these substances may cause damage.
- To clean PV modules effectively and without causing damage, use a dry or wet, soft, and clean cleaning cloth, sponge, or a soft-bristled brush to gently wipe the modules. Ensure that cleaning tools do not cause wear to glass, EPDM, silicon, aluminum alloys, or steel. Do not use corrosive solvents for cleaning. Avoid wiping PV modules with hard objects. The module must not be subjected to additional external force during cleaning. If greasy dirt or other substances are hard to clean, conventional household glass cleaning agents may be used. Do not use alkaline and strong acid solvents, including hydrofluoric acid and acetone. If necessary, use iso-Propyl alcohol (IPA) or another solution following safety instructions. Ensure no solution flows into the gap between the module edge and the module frame.
- When cleaning the modules, use a soft cloth together with a mild detergent and clean water. Take care to avoid severe thermal shocks which might damage the module by cleaning modules with water which make sure the temperature difference between the water and the module is in the range of -5°C ~10°C. For example, do not use cold water to clean the module when the temperature of it is high during the day as there is a risk of damaging the module.
- Do not clean PV modules during weather conditions with wind speeds exceeding 4 on the Beaufort scale, heavy rain, or intense snowfall.
- When cleaning, do not step on the modules, do not spray water on the backside of the module or the cables, keep the connectors clean and dry, prevent fire and electrical shock from occurring, and do not use a steam cleaner.
- The back surface of the module normally does not need to be cleaned. However, in the event this is deemed necessary, avoid the use of any sharp objects that might damage or penetrate the substrate material. When cleaning the back surface of the module, take care to avoid penetrating the substrate material. The other cleaning requirements are the same as the front-side.
- Do not scrape or grind stains off surfaces while PV modules are dry, as this can cause minor scratches on the surface.

The following table list some common cleaning methods:

Method	Description	Requirements
Method A	Compressed water	pH: 6~8; Chloride or salt content: 0 ~3000 mg/L; Turbidity: 0~30 NTU; Conductivity: 1500~3000 μ s/cm; Total dissolved solids (TDS): \leq 1000 mg/L; Water hardness (calcium and magnesium ions): 0~40 mg/L Recommendation: Use soft water to wash. Water pressure on the glass surface of the module must not exceed 700 KPa.
Method B	Compressed air	IMPERIAL STAR SOLAR recommends using this method to clean soft dirt (dust) on modules. This technique can be applied as long as the method is efficient enough to clean the modules considering the on-site conditions.
Method C	Wet cleaning	If excessive soiling is present on the module surface, a non-conductive brush, sponge, or other mild agitating method may be used with caution. Make sure that any cleaning tools are constructed with non-conductive materials to minimize the risk of electric shock and that they are not abrasive to the glass or the aluminum frame. If grease is present, an environmentally friendly cleaning agent may be used with caution. Do not use alkaline and strong acid solvents. If necessary, use iso-Propyl alcohol (IPA) or another solution according to the safety instructions to clean and ensure that no solution flows into the gap between the edge of the module and the module frame.
Method D	Cleaning robot	If a cleaning robot is used for cleaning, choose a robot with brushes made of soft plastic material. Brands like Dupont are known for producing high-quality materials suitable for various applications. Ensure the cleaning method involves wet cleaning. Use products that ensure that the cleaning process does not scratch the glass surface and aluminum alloy frame. Keep the weight of the cleaning robot within acceptable limits. A lighter robot is generally easier to maneuver and reduces the risk of potential damage to the solar modules. In the event of improper usage of the cleaning robot, any resultant damage to the modules and reduction in power output will not fall under the coverage of IMPERIAL STAR SOLAR's warranty.

NOTES:

1. Conduct a visual inspection to ensure that the module is clean, bright, and free of stains.
2. Perform spot checks to verify the absence of soot deposits on the module surface.
3. Examine the module surface for any visible scratches.
4. Check for the presence of man-made cracks on the module surface.
5. Inspect the module support structure for signs of leaning or bending.
6. Verify that the connectors of the module are securely attached.
7. Keep a record of all cleaning events, noting the time, general summary of tasks performed, and the personnel carrying out the tasks.

Table: Common cleaning methods

8. DOCUMENT VERSION CONTROL

The R&D Department of IMPERIAL STAR SOLAR maintains version management of this document, and reserves the right to final interpretation of this document. Ensure that the most current version of this document is used for reference and implementation.



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