

PT/T-0001-2024_2.1

Installation and Maintenance Manual

of PV Modules



Change History

No.	Details	Prepared by	Version	Effective date
01	New document	Product Department	1.0	2024-08-01
02	-Add the models covered by this manual -Add Section 5 Unloading, Transshipment, Storage and Unpacking -Add the test load of different models in Section 7.2 -Add cleaning method in Section 9.3	Quality Management Department	2.0	2024-11-01
03	Add note about tolerance of the Modules and provide suggestions in Section 7.2.2	Quality Management Department	2.1	2024-12-01

This Installation and Maintenance Manual applies to the following models:

Type	Module model		Dimension (mm)
Dual-glass series	Anodized aluminum alloy framed	SG-48TG4D-XXX	1762*1134*30
		SG-54TG1D-XXX	1722*1134*30
		SG-54TG4D-XXX	1961*1134*30
		SG-72TG1D-XXX	2278*1134*30
		SG-66TG4D-XXX	2382*1134*30
		SG-78TG1D-XXX	2465*1134*30
	Composite material framed	SG-48TG4D-XXX	1762*1134*30
		SG-54TG1D-XXX	1722*1134*30
		SG-54TG4D-XXX	1961*1134*30
		SG-72TG1D-XXX	2278*1134*30
		SG-66TG4D-XXX	2382*1134*30
		SG-78TG1D-XXX	2465*1134*30
Single-glass series	Anodized aluminum alloy framed	SG-48TT4D-XXX	1762*1134*30
		SG-54TT1D-XXX	1722*1134*30
		SG-54TT4D-XXX	1961*1134*30
		SG-72TT1D-XXX	2278*1134*30
		SG-66TT4D-XXX	2382*1134*30
		SG-78TT1D-XXX	2465*1134*30
	Composite material framed	SG-48TT4D-XXX	1762*1134*30
		SG-54TT1D-XXX	1722*1134*30
		SG-54TT4D-XXX	1961*1134*30
		SG-72TT1D-XXX	2278*1134*30
		SG-66TT4D-XXX	2382*1134*30
		SG-66TT4D-XXX (Dustproof)	2382*1134*30
		SG-78TT1D-XXX	2465*1134*30

Note:

1. XXX means the nominal power on the nameplate, graded by 5W. The power range depends on the certificate.
2. Due to product updates, the models may be added or changed without prior notice from Sungrow Renewables Development Co., Ltd.

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1 Manual Description

- This manual only applies to the photovoltaic modules (hereinafter referred to as “Module” or “Modules”) of the Photovoltaic Technology Division of Sungrow Renewables Development Co., Ltd. (hereinafter referred to as “Sungrow Renewables”). This manual contains information on the installation method, operation safety and maintenance instructions of Sungrow Renewables Modules. Please read the following installation instructions carefully before installing and maintaining the Modules.
- Installation and operation of the Modules requires specialized skills and shall only be performed by professionals who are familiar with the mechanical and electrical requirements during installation. The installers must strictly follow the instructions of this manual, as well as local laws and regulations or relevant requirements of authorized agencies.
- Please keep this manual in a safe place for future maintenance as well as for sale or disposal of the Modules.

2 Disclaimer

- This manual does not constitute any warranty, whether express or implied. Failure to operate the Modules in accordance with the requirements in this manual will void the Limited Warranty provided to the customer. Sungrow Renewables is not liable for any losses arising from the installation, operation, use or maintenance of the Modules due to failure to follow this manual, including personal injury, malfunction or damage of the Modules, or any other costs incurred.
- No customer shall obtain a patent or patent license through the use of this manual (whether express or implied). Liability related to infringement of third parties' patents or other rights arising from the use of the Modules and this manual shall not be borne by Sungrow Renewables.
- Sungrow Renewables reserves the right to update this manual without prior notice.

3 Identification of the Modules

There are 3 types of labels affixed to each Module, providing information as follows:

- Nameplate: each Module has a nameplate, which indicates the model, electrical parameters and safety specification, as follows:

SUNGROW Model: SG-66TG4D-615		STC	BNPI	aBSI	Power selection:	0~+5W
     SUNGROW RENEWABLES DEVELOPMENT CO.,LTD. Add: No.2 Tianhu Road, New & High Technology Industrial Development Zone, Hefei, P. R. China Modules are certified to IEC61215:2021 and IEC61730:2023 Certificate Number: Z2 116128 0016 Rev. 02 Made in China	Maximum power(P _{max}):	615W(±3%)	677W(±3%)		Maximum system voltage:	1500V
	Maximum power voltage(V _{mp}):	41.10V	41.10V		Maximum series fuse rating:	30A
	Maximum power current(I _{mp}):	14.98A	16.48A		Connector Type:	Z4S-ab0d
	Open circuit voltage(V _{oc}):	49.30V(±3%)	49.30V(±3%)		Connector Manufacturer:	Zerun Co.,Ltd.
	Short circuit current(I _{sc}):	15.89A(±3%)	17.48A(±3%)	18.42A(±3%)	Weight:	32.4KG
	Bifaciality coefficient η _{Pmax} :		80%±10%		Dimension:	2382*1134*30mm
	Bifaciality coefficient η _{isc} :		80%±10%		Fire test:	Class C
	Bifaciality coefficient η _{Voc} :		100%±3%		Safety Class:	II
	STC: AM1.5 1000W/m ² Temp 25°C				Module(T98) max:	70°C
	BNPI: AM1.5 Front 1000W/m ² Rear 135W/m ² Temp 25°C				Min.Design Load:	+3600/-1600Pa
	aBSI: AM1.5 Front 1000W/m ² Rear 300W/m ² Temp 25°C				See manual for instructions	
					Nameplate is placed on rear side of the module	

- Serial number: each Module has a unique serial number and barcode, and it is laminated on the busbar on the front top. The serial number and barcode can also be found on the back sheet and the frame.
- Current grading sticker: the Modules are graded based on the optimal working current, and there are three

values, namely, H, M and L (H means the highest current grade). The best practice during installation is to install the Modules labeled with the same current grading (e.g. all H) in one string. For the last remaining Modules with different current grading, it is suggested that Modules with adjacent current grading be installed in one string.

4 Module Safety

4.1 General Safety Rules

4.1.1 The Sungrow Renewables Modules are designed in accordance with the standards of IEC 61215 and IEC 61730 of the International Electrotechnical Commission. The application level is Class A, which means the Modules can be used in systems with a DC voltage greater than 50V or a power output more than 240W, which may be exposed to the public. The safety class of the Modules is Class II, and the fire rating is Class C.

4.1.2 No matter whether the Modules are connected to the system or not, there should be appropriate protective measures when you touch the Modules, such as insulated tools, safety helmets, insulated gloves, safety belts and insulated shoes. When you have operations like installation, grounding, wiring or cleaning of the Modules, make sure to use proper electrical protection tools. Do not touch the Modules directly, otherwise it may cause electric shock or cuts.

4.1.3 For your safety, do not install or handle the Modules under dangerous conditions, including but not limited to, strong winds or gusts, or on wet or sandy roofs.

4.1.4 Do not try to disassemble the Module or remove the nameplate or any part on the Module. Do not paint or apply any adhesive to the surface of the Module. Please avoid damage to the back sheet of the Module. Do not scratch or scuff the back sheet of the Module.

4.1.5 Do not drill holes on the frame without authorization from Sungrow Renewables, otherwise it may lead to frame corrosion or other negative effects on the Module.

4.1.6 Do not scratch the anodic oxide layer on the surface of the aluminum alloy frame, as scratching may lead to frame corrosion, which will affect the load capacity of the Module.

4.1.7 Do not repair the Modules with damaged glass or back sheet by yourself. Scrapped Modules should be recycled and disposed of by qualified institutes.

4.1.8 Crossed-out wheeled dustbin: this mark means do not dispose of this electrical appliance as unsorted municipal waste. Use separate collection facilities. Please contact the local authority for information on available collection facilities. If electrical appliances are disposed of in a landfill or junkyard, hazardous substances may leak into the groundwater and get into the food chain, damaging your health and well-being. When an old appliance is replaced with a new one, the retailer is legally obliged to take back your old appliance for disposal at least free of charge.

4.2 Electrical Performance Safety

4.2.1 The Modules will generate DC current in the sunlight. Please take appropriate protective measures

(insulated gloves, insulated shoes, etc.) to prevent personnel from direct contact with 30V or higher DC voltage, which can be lethal.

4.2.2 The Modules can still generate voltage even when no load or external circuit is connected. Please use insulated tools and wear rubber gloves when operating the Modules in the sunlight.

4.2.3 The Modules do not have switches, and they will stop working only when kept from sunlight or covered by cloth, hard board or UV-proof materials.

4.2.4 To avoid electric arc and shock, please do not break down electric connection in loaded conditions. Incorrect connections will also lead to electric arc or shock. Keep connectors dry and clean and make sure they are in good operating conditions. Do not insert other metals into the connectors or have electric connection by whatever means.

4.2.5 Snow, water or other reflective medium in surrounding environment will intensify irradiated light received by the Modules, thus increasing current output. The Modules' voltage and power output will also increase under low temperature conditions.

4.2.6 If the glass or encapsulating materials of the Modules is damaged, please wear personal protective equipment and isolate the Modules from the circuit.

4.2.7 The Modules can only be installed and maintained in dry conditions using dry tools. Do not operate when the Modules are wet unless you wear qualified personal protective equipment. Please follow the cleaning requirements in this manual when cleaning the Modules.

4.2.8 Do not wear metal rings, watch bands, earrings, nose rings or other metal objects when installing or troubleshooting the PV system.

4.2.9 The Modules must be installed under the instruction of a qualified electrician.

4.2.10 No matter what weather condition is, personnel entering the power station shall wear safety helmet, insulated gloves and insulated shoes correctly for personal security.

4.3 Transport and Handling Safety

4.3.1 Do not open the packing box until the Modules have arrived at the installation site. Please transport the Modules properly and protect the package from damage, otherwise it may cause damage to the Modules.

4.3.2 When pallets of Modules need to be stacked, do not exceed the maximum layers as printed on the packing box. Before opening the box, put the Modules in a ventilated, dry and rainproof place.

4.3.3 Do not climb, stand, walk or jump on the packing box and the Modules, which may damage the Modules and cause personal injury.

4.3.4 Handle and install the Modules gently. Under no circumstances should the Modules be lifted by grasping the junction box or wires.

4.3.5 During the handling processes, make sure the Modules are not subjected to significant vibrations, dropped

onto the ground, or impacted by falling objects, as this may cause damage to the Modules or the cells inside. Be careful when placing the Modules on the ground to prevent them from falling. Broken glass may injure people, and Modules with damaged glass shall not be used. Broken or damaged Modules should be handled carefully and disposed of specially.

4.3.6 The Module should be handled by two or more people holding its edge with both hands.

4.4 Installation Safety

4.4.1 The Modules shall be installed in accordance with the laws and regulations specified by the relevant local and national authorities of the installation site. If necessary, the required documents such as construction permission should be obtained first.

4.4.2 It is suggested that the Modules be installed by professionals with experience in PV system installation. Take protective measures such as wearing protective headgear, insulated gloves and insulated shoes during installation.

4.4.3 Do not wear metal jewellery when installing or servicing the PV system, as this may poke through the Module and cause electric shock.

4.4.4 Before installation, make sure that all Modules and electrical connectors are clean and dry.

4.4.5 Do not install or operate the Modules in rain, snow or windy conditions. If the Modules are installed or operated after rain or on dewy mornings, please take proper protective measures to avoid moisture permeation into the connectors.

4.4.6 Once the Modules are taken out from the box, please install and connect them to the inverter in time, or if not, please well protect the connectors (e.g., by adding rubber caps).

4.4.7 Do not drop any tools or other objects on the front or back of the Module, as this may cause visible or invisible damage to the Module. When placing a piece of Module on a flat surface, especially in corner areas, handle it carefully.

4.4.8 Before installation, carefully check the Modules and make sure there is no broken glass, cell crack, scratches on the back sheet, deformation of the mounting holes, dislodged junction boxes, missing box covers, dislodged or missing nameplates, damaged cables and connectors.

4.4.9 Do not install or use damaged Modules. If the glass is broken or worn, direct contact with the surface of the Module may cause electric shock.

4.4.10 When using a scaffold for installation, make sure the scaffold is placed on a flat surface or there are anti-tipping measures. The installer should wear a safety belt in accordance with the local regulations on construction. Do not stand on the lower side of the tilted Module during installation, otherwise you may get injured if the Module slips off.

4.4.11 When the Modules are installed on the roof, the overall fire rating of the final structure needs to be considered, as well as the overall maintenance in the future. The roof on which the PV system is to be installed

must be assessed by a construction expert or engineer, with a formal and complete structural analysis and be proven to be able to withstand the weight of the PV system, including the weight of the Modules.

4.4.12 For your safety, do not work on the roof without protection measures, including but not limited to fall protection, ladders or stairs and personal protective equipment.

4.5 Fire Safety

4.5.1 Before installing the Modules, please consult the local laws and regulations and follow the requirements regarding the fire resistance of the building.

4.5.2 According to the IEC 61730-2 standard, the fire rating of the Sungrow Renewables Modules is Class C. When the Modules are installed on a roof, the roof must be covered with a layer of fireproof material suitable for the installation and fire rating of the Modules. Make sure there is adequate ventilation between the back sheet of the Modules and the surface on which they are installed.

4.5.3 Differences in the roof structure and the installation method may affect the fire safety of the building. If the Modules are not properly installed, a fire may result.

4.5.4 The minimum distance between the Module frame and the roof surface is 10cm to facilitate ventilation and heat dissipation of the Module and ensure the fire rating of the Module on the roof.

4.5.5 Please use proper accessories such as fuses, circuit breakers, and grounding connectors as required by local regulations.

4.5.6 Do not store, install or use the Modules in a place where flammable gases are likely to be generated or gathered.

5 Unloading, Transshipment, Storage and Unpacking

Please follow this manual and the local laws and regulations of the installation site for unloading, transshipment, storage and unpacking of the Modules. Sungrow Renewables shall not be liable for any damages arising due to failure to follow this manual, including personal injuries, malfunctions or damages of the Modules, or any other costs incurred.

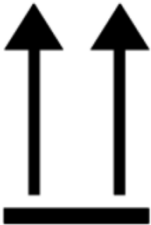
5.1 Package

➤ The Sungrow Renewables Modules are in horizontal package as follows:



Fig. 1 Horizontal package

➤ Box labeling:

			
Keep the package upright during transport and storage	The Modules in the box are fragile. Handle them gently.	Do not expose the Modules to rain or moisture.	At most two pallets of Modules are allowed to be stacked.

5.2 Unloading

- After the Modules arrive at the site, please check the outer package in time. Check whether the model and quantity of the Modules on the outer package are consistent with those on the delivery note. If the package is damaged, deformed or skewed, keep the information and contact relevant personnel as soon as possible.
- The Modules should be unloaded in a flat, solid, open and clear field, which is convenient for the crane and forklift operator to observe and operate.

5.2.1 Unloading by crane

5.2.1.1 When unloading the Modules by crane, please use a lifting rope with sufficient tension based on the weight and size of the Modules. The lifting rope should be a long nylon sling. Do not use wire rope.

5.2.1.2 The sling should be supported on the top of the packing box by a wooden board of the same width as the outer packing box or other special tools to prevent it from squeezing the Modules inside the box (see Fig. 2). Before lifting, check whether the pallet and box are damaged, whether the sling is strong and firm, and whether the length of the sling is evenly distributed on both sides of the packing box. The sling should not be too close to the middle or edge of the box. Please adjust the position of the sling to keep the center of gravity of the Modules stable.



Fig. 2 Diagrammatic sketch of lifting the Modules

5.2.1.3 Keep the box balanced when lifting, as tilting of the box may damage the Modules.

5.2.1.4 During unloading, there should be a person special for guidance. The crane operator and the guiding officer shall have professional operating licenses. Keep gentle as much as possible during unloading, otherwise the Modules may fall or be damaged. When the box is close to the ground, two persons should hold the box and gently put it on the flat ground.

5.2.1.5 Do not lift the Modules under strongly windy (with Beaufort wind force scale greater than 6), heavily rainy or snowy conditions. Please strictly follow the requirements in *Safety Rules for Lifting Appliances*.

5.2.1.6 For horizontal package, it is allowed to lift two pallets of Modules at most at a time.

5.2.2 Unloading by forklift

5.2.2.1 Please use suitable forklift based on the size and weight of the Modules for loading and unloading. If the fork length is less than 3/4 of the size of the Modules, set extended fork sleeves before operation to avoid tipping of the packing box when the forklift is moving.

5.2.2.2 During loading and unloading, except for the forklift operator, others should stay away at a safe distance to ensure personal security. People are not allowed to stand on either side of the forklift or pass by near the forklift during operation. There should be a person special for guidance during loading and unloading to prevent damaging the Modules, and the forklift operator shall have professional operating licenses.

5.2.2.3 During operation, the distance between the two forks should be adjusted as needed, so that the loads on the two forks are balanced and the Modules will not be skewed. Please place cushioning materials (see the blue part in Fig. 3) between the forklift rack and the packing box in advance to prevent Module damage due to external force, and it is recommended that the materials be silicone rubber, rubber and EPE. The packing box should be close with the cushioning material.

5.2.2.4 During operation of the forklift, please avoid sharp objects (especially the forks) contact or collision with the packing box body, otherwise it may damage the Modules inside (see Fig. 4).

5.2.2.5 When a forklift is used to move the palletized packing box to the working area, make sure the operation is slow, steady and gentle, and avoid bumps and severe vibration during transport.

5.2.2.6 When unloading the Modules from a container, keep the whole pallet balanced and the forklift arm horizontal. Move out the Modules from the container slowly and steadily with the forklift.

5.2.2.7 When unloading the Modules from a container, make sure there is a spacing of 2-3cm between the packing box and the wall of the container and the neighboring boxes, and then move backward slowly to prevent friction between the packing box and the wall of the container or the neighboring boxes, otherwise it may cause damage to the packing box.

5.2.2.8 During unloading, please control the driving speed of the forklift to prevent the Modules from toppling over and causing injuries to personnel when turning. The driving speed of the forklift should be $\leq 5\text{km/h}$ in a

straight line and $\leq 3\text{km/h}$ in a turn. Do not have sharp stops and starts.

5.2.2.9 When unloading the Modules on a platform, the height of the platform should be the same as the height of the bottom of the truck. If there is any height difference, use steel plate pads or other work tools to facilitate the Modules being moved out from the container smoothly. When the Modules are going to be out of the container mouth, make sure the gap between the platform and the bottom of the truck will not cause bumps. Please note the distance of the top of the packing box and the roof of the truck to avoid collision.

5.2.2.10 When the Modules are placed after unloading, make sure there is enough spacing between neighbouring pallets to avoid collision of packing boxes or pallets.



Fig.3 Set Cushioning materials



Fig. 4 Do not touch the box body with forks

5.3 Transshipment

5.3.1 If the Modules need to be transported over a long distance or stored for a long time, do not remove the original package and keep the packing box intact.

5.3.2 The well-packaged Modules can be transported by land, sea or air. Please firmly fix the packing box on the carrier during transport.

5.3.3 Do not remove the original package if the Modules are to be transported at the site. Please firmly fix the packing box on the carrier. Do not use tricycles to transport the Modules.

5.3.4 If vans or other types of vehicles are used for transshipment, make sure they have guard rails. The height of the guard rails should not be lower than $2/3$ of the height of the Modules. Use fastening straps to fix the Modules with the carriage, and use paper corner protectors or other cushioning materials to protect the part of the packing box in contact with the fastening straps. When transported in small trucks, the Modules are not allowed to be stacked.

5.3.5 If the unpacked Modules need to be transported, first put the Modules on the pallet, pack the Modules, then pack the Modules with the pallet, and finally put on the packing box. You can refer to the original package for the packing method and number of Modules to be packed. Do not put the under-filled pallet (the number of modules on the pallet is less than the normal value) on the lower layer during transport.

5.3.6 Single-glass Modules in horizontal package are not allowed to be transshipped.

5.3.7 During transport, make sure the pallets are placed closely with each other. Use foam to fill the gaps

between the packing box and the wall of the truck or container.

5.3.8 Do not place the pallets out of the loading area of the transportation vehicle.



Fig. 5 Do not use tricycles to transport the Modules



Fig. 6 Please firmly fix the Modules

5.4 Storage

5.4.1 Due to the complex environmental and climatic conditions of the project site and for better security, it is suggested that the pallets of Modules be stored in a single layer, and there should be regular on-site inspection.

5.4.2 The Modules should be stored in intact package and on flat and dry ground. The environment should be dry and ventilated. Protect the Modules and pallets from moisture and direct sunlight and take waterproof and rainproof measures.

5.4.3 Do not store the Modules on soft or easily collapsible ground. Choose hard ground or ground with high terrain, and level the ground to ensure the Modules do not collapse or tilt in long-term storage.

5.4.4 Do not soak the pallets in water, and the storage area should be well drained to prevent the accumulation of water after rain from causing wood rotting or ground sinking, which will lead to tipping of the Modules.

5.4.5 Do not stack other objects on the Modules or packing boxes.

5.4.6 Long-term storage of the Modules in outdoor environments may result in the Modules tipping over. For long-term storage, it is suggested that the Modules be stored in standard warehouses with regulation on-site inspection. If the Modules tip over, please ensure personal security and then righting the Modules.

5.4.7 It is suggested that the Modules be stored in a centralized place, and unauthorized people are not allowed to enter the storage area.

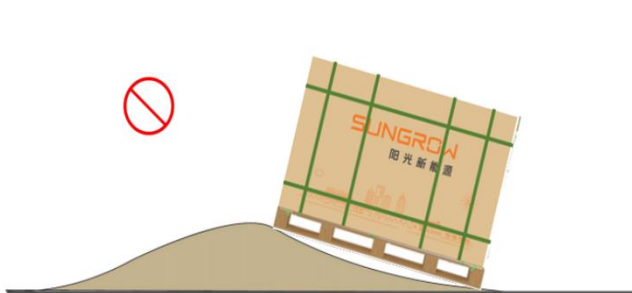


Fig. 7 Do not store the Modules on uneven ground



Fig 8. Please take rainproof measures

5.5 Unpacking

5.5.1 Notice

5.5.1.1 Before unpacking, please check the shipping mark posted on the box to confirm the Module model, power, quantity and serial numbers. Check whether the packing box is intact, and unpack the Modules according to the instructions in this manual. Violent operations are not allowed, otherwise it may damage the Modules inside the box.

5.5.1.2 The working floor should be flat so that the packing boxes can be placed stably.

5.5.1.3 Please wear protective gloves during the unpacking process to avoid scratching your hands and leaving fingerprints on the glass. At least two persons are required for the unpacking.

5.5.1.4 Before unpacking the Modules, place a special support on the back of the Modules, and make sure the support will not scratch or break the Modules. Do not lean the Modules against the mounting pillars or use wooden strips to support on the back of the Modules. After taking out the Modules from the box, place them against the special support. Do not move the special support during unpacking, otherwise it may cause the Modules to tip over.

5.5.1.5 When unpacking outdoors, do not work under rainy or snowy conditions. If it is windy, pay special attention to safety, especially under strongly windy conditions, it is not recommended to unpack and handle the Modules, and the unpacked Modules should be properly fixed.

5.5.1.6 If not all Modules are taken out of the packing box, the remaining Modules should be horizontally placed and then repacked to prevent tipping. For packing, the glass side of the Module on the bottom should be facing up, the glass side of the other Modules should be facing down, and the glass side of the Module on the top should be facing up. The maximum number of Modules packed together should not exceed 16 pieces.

5.5.1.7 When unpacking, the operators are not allowed to stand behind the Modules which are leaned against the special support.

5.5.1.8 When removing the strapping, be careful not to get scratched. Before removing the internal strapping, take precautions to prevent the whole box of Modules from tipping over.

5.5.1.9 The operators are not allowed to stand on the pallet during unpacking. Please stand beside the pallet and handle the Modules.

5.5.1.10 After unpacking, do not expose the connectors of the Modules to any unauthorized chemicals.

5.5.1.11 Do not handle the Module by lifting its wires or junction box. You can handle the Module by holding the short frames.

5.5.1.12 Do not remove the corner protectors from the Module before installation.

5.5.1.13 The remaining Modules after installation should be stored in a centralized area and protected in

packing boxes.

5.5.2 Instructions of unpacking and handling

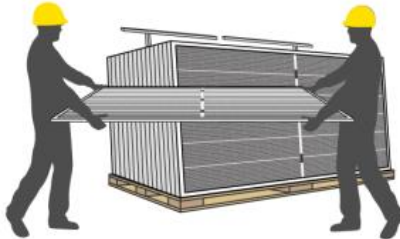
 ① Cut the strapping with scissors	 ② Remove the top cover and box
 ③ Place a special support on the back of the Modules and insert it into the bottom of the pallet. The support should be higher than the Modules, otherwise it may damage the back of the Modules.	 ④ Cut all horizontal strapping.Slowly lean the Modules against the support.
 ⑤ Cut all remaining strapping	 ⑥ Handle the Modules one by one from the outermost side

Fig. 9 Instructions of unpacking

6 Installation Requirements

6.1 Installation Environment

6.1.1 Generally, the Modules should be installed in a place that receives the maximum light throughout the year. When selecting a site, do not choose those with trees, buildings or other obstacles that would cast shadows on the Modules. Shadows can result in a loss of power output, and despite there are bypass diodes in the Module,

shadows can affect the optimal performance and operational safety of the Module. It is not recommended to install the Modules in a place with permanent shadows. Module damage caused by prolonged shading is not covered by Sungrow Renewables' warranty.

6.1.2 Do not use mirrors or magnifiers to artificially focus sunlight on the Modules.

6.1.3 It is recommended that the Modules be installed in an environment with a temperature of $-20^{\circ}\text{C}\sim+46^{\circ}\text{C}$, which is the average monthly minimum and maximum temperature of the installation site. The operating temperature of the Modules is $-40^{\circ}\text{C}\sim+70^{\circ}\text{C}$. 98th percentile operating temperature: 70°C .

6.1.4 The Modules should be installed in suitable places (e.g. on the ground, PV tracking systems, roofs or building walls). Do not install the Modules on movable vehicles of any type.

6.1.5 The Modules can be installed in fishery-solar hybrid projects or floating projects in freshwater environments and on land at a distance of 50-500m from the sea, but the connectors need to be protected or set with dust plugs in such cases. Connections must be made immediately after removing the dust plugs, and other anti-rust measures should be taken to prevent rusting of relevant parts.

6.1.6 Do not install or use the Modules in environments with strongly corrosive substances, such as salt, salt spray, salt water, active chemical vapors, acid rain, or any other substance that would corrode the Modules and affect their safety or performance.

6.1.7 The Modules must be protected against thunderstroke if installed in an area with frequent lightning. Do not install the Modules in a location where there may be flammable gases in the vicinity.

6.1.8 When the Modules are installed in environments with heavy snow, extreme coldness, strong winds, or harsh environments such as near water, on islands near salt spray, or in deserts, please use proper protective measures to ensure the reliability and safety of the Modules. Corrosion may occur at the part where the Module frame and the bracket connects, or at the part where grounding is made.

6.1.9 The maximum altitude of the installation site should be $\leq 2000\text{m}$.

6.1.10 Make sure the pressure of wind or snow to which the Modules are subjected after installation does not exceed the maximum allowable load. The mechanical load that the Modules can withstand depends on the installation method. The mechanical load should be calculated and the installation method should be designed by professionals during the design of the PV system.

6.1.11 Do not install the Modules in a location where they will be immersed in water or continuously exposed to sprinklers or fountains.

6.1.12 When installing the Modules on a roof, keep a safe working area between the edge of the roof and the outer edge of the PV array.

6.2 Decide the Tilt Angle

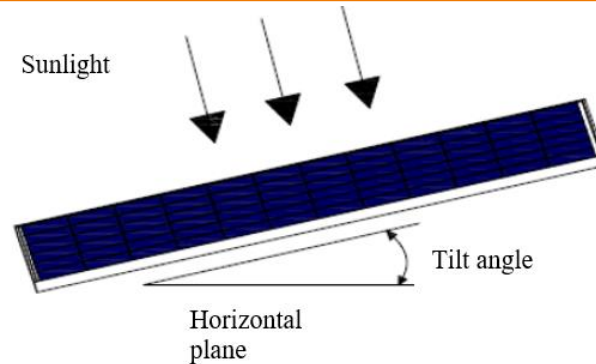


Fig 10. Diagrammatic sketch of the tilt angle

6.2.1 The tilt angle means the angle between the surface of the Module and the horizontal plane. When the Module is directly facing the sunlight, it will get the maximum power output. It is recommended that Modules to be installed in the northern hemisphere face south, and Modules to be installed in the southern hemisphere face north.

6.2.2 The Modules installed in the same string should have the same tilt angle. Modules installed at different tilt angles will receive different amounts of irradiation, which will lower the efficiency of the system.

6.2.3 It is recommended that the Modules be installed at a tilt angle of not less than 10 degree, so that when it rains, dusts on the Module surface will be easily taken away by the rain, thus reducing the frequency of Module cleaning. Meanwhile, water on the Module surface also easily flows down at this angle, and there will be less water stains on the glass caused by accumulation of water, which affects the appearance and performance of the Modules.

6.2.4 In order to get the maximum power output, please select the optimal orientation and tilt angle based on the location where the Modules are to be installed to ensure that the sunlight can still reach the Modules even on the shortest day of the year. For standalone systems, the tilt angle should be decided based on the changes of the season and sunlight to optimize the system performance. Generally, if the Modules installed at a tilt angle have adequate power output even when the irradiance is the lowest in the year, such tilt angle will enable the Modules to have adequate power output in the rest of the year. For grid-connected systems, the tilt angle should be decided based on the principle of optimizing the power output throughout the year.

6.2.5 Please consult professional PV installers or system integrators for detailed information on the optimal tilt angle.

7 Mechanical Installation

7.1 General Requirements

7.1.1 Make sure the installation method of the Modules is reliable and the brackets are firm and strong, so the Modules can withstand the intended load. The bracket installer or supplier should provide the necessary warranty and associated certification. The bracket system must be inspected and tested by a third-party testing institute with static mechanical analysis capability and comply with national or regional standards.

7.1.2 The Modules must be securely installed on the brackets and the brackets should be made of durable, rust and corrosion resistant, and UV resistant materials.

7.1.3 In areas where there are heavy snows in the winter, please use higher brackets for installation. In this way the lower side of the Modules will not be covered by snow for a long period of time. Besides, this will make the Modules less likely to be shaded by trees and other plants or damaged by flying sand and rolling stones.

7.1.4 The frames of the Modules are subject to the thermal expansion and contraction effect, therefore please keep a spacing no less than 10mm between the frames of two adjacent Modules during installation.

7.1.5 Make sure the back sheets of the Modules will not touch the brackets or building structures, especially when there is an external pressure on the surface of the Modules.

7.1.6 Do not drill holes in the glass or frame of the Modules, otherwise the warranty will be voided.

7.1.7 When the Modules are installed on a roof, make sure the roof structure is suitable. In addition, the part of the roof to be penetrated for the installation must be properly sealed to prevent roof leaks.

7.1.8 Do not block the drainage holes in the frame during installation.

7.1.9 The maximum static loads withstood by the Modules are 2400Pa (equivalent to wind pressure) on the back and 5400Pa or 2400Pa (equivalent to snow and wind pressure) on the front, depending on the installation method (refer to Section 7.2). The load described in this manual is test load. According to the installation requirements of IEC 61215-2:2016, a safety factor of 1.5 needs to be included when calculating the maximum design load, i.e. design load = test load/1.5 (safety factor).

7.1.10 The Modules can be horizontally or vertically installed.

7.2 Installation Method

The Sungrow Renewables Modules with aluminum alloy frame can be installed with bolts or clamps, while the Modules with composite material frame can only be installed with clamps.

7.2.1 Installation with bolts

- The aluminum alloy framed Modules with 66 pieces of cells are set with four 14mm*9mm mounting holes and eight 10mm*7mm mounting holes, while the aluminum alloy framed Modules with 72 and 78 pieces of cells are set with eight 14mm*9mm mounting holes and four 10mm*7mm mounting holes. The Modules can be installed on the brackets with the mounting holes in the frame.
- The M8 bolt kits should be used for the 14mm*9mm mounting holes, and the M6 bolt kits should be used for the 10mm*7mm mounting holes.
- If the Modules are installed with bolts, make sure there are four bolts at least on each Module. The bolts should be symmetrically arranged, and different mounting positions of the bolts will affect the maximum load capacity of the Modules.
- The torque used should be high enough to securely fasten the Modules. For reference, the torque for M8

bolts is 16-20 N·m, and for M6 bolts is 9-12 N·m. If special brackets or special installation methods are used, please check the torque value with the bracket supplier.

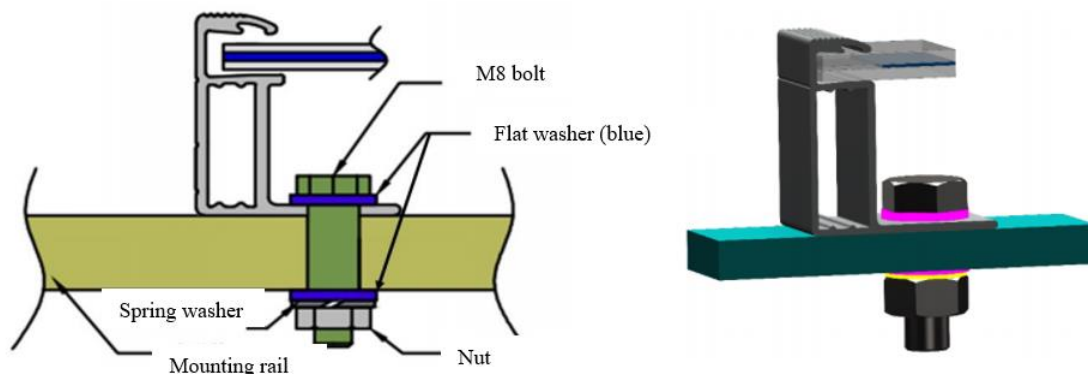


Fig. 11 Diagrammatic sketch of installation with bolts

- The bolt kits are recommended as follows:

Fastener	M8 bolt kit	M6 bolt kit	Remark
Bolt	M8 (full thread is recommended)	M6 (full thread is recommended)	The material should be hot-dip galvanizing or stainless steel based on the local environment.
Flat washer	2*M8 thickness $\geq$ 1.5mm outer diameter $\geq$ 16mm	2*M6 thickness $\geq$ 1.5mm outer diameter 12-16mm	
Spring washer	8mm	6mm	
Nut	M8	M6	
Torque reference (N·m)	16~20	8~12	

- It is recommended that the Modules be installed using the four outer mounting holes, and the mounting rail be vertical to the long frame of the Module (the following sketch is about Modules with 66 pieces of cells).

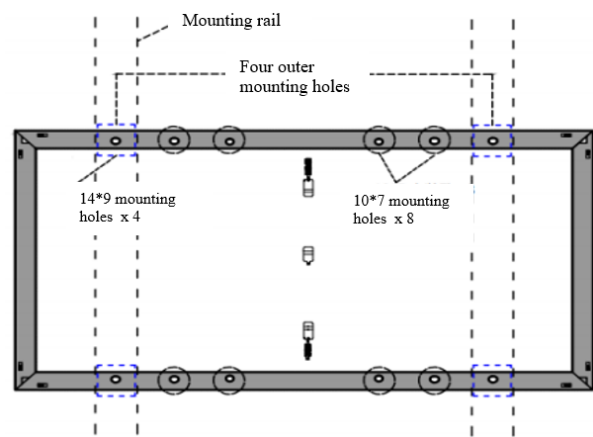


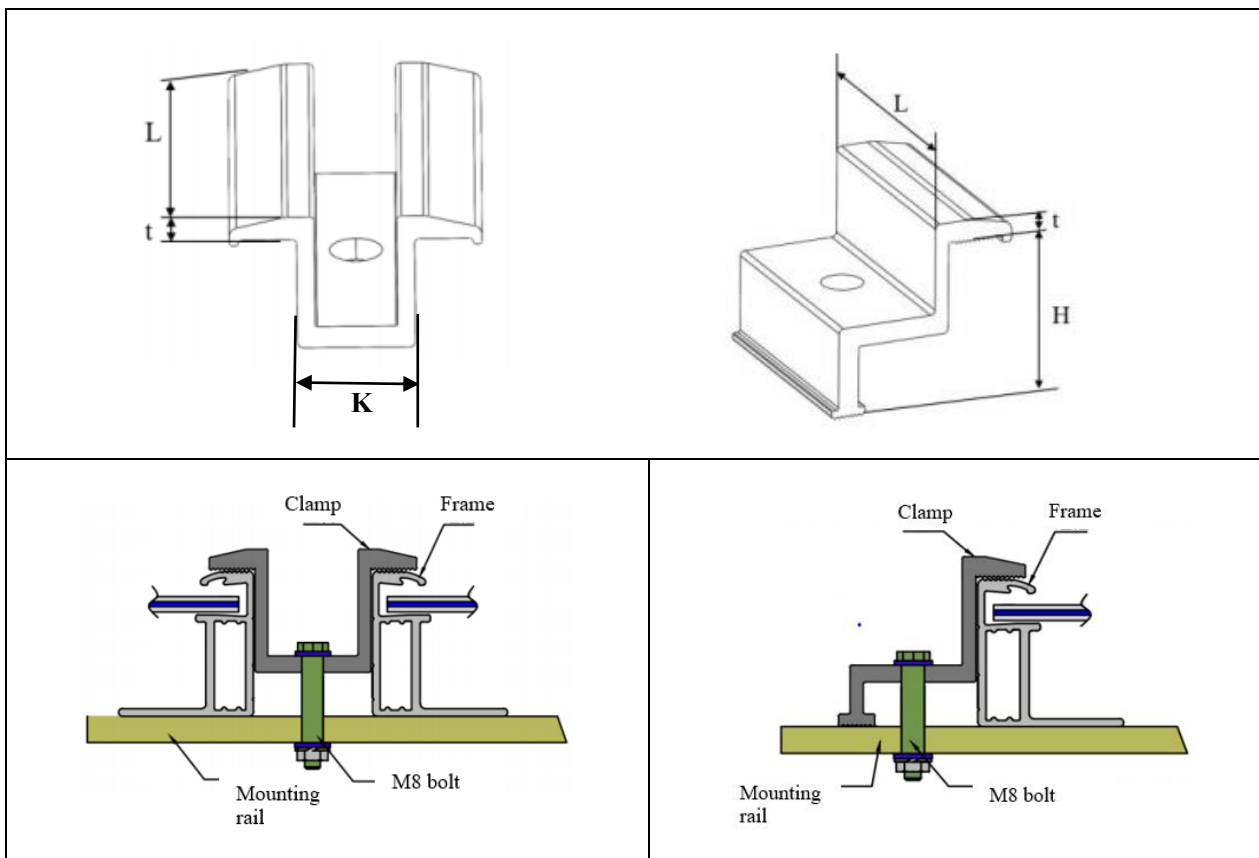
Fig. 12 Diagrammatic sketch of installation with bolts

Module model		Installation with bolts using the four outer mounting holes
		Test load front/back (Pa)
Anodized aluminum alloy framed	SG-48TG4D-XXX	+5400/-2400
	SG-54TG1D-XXX	+5400/-2400
	SG-54TG4D-XXX	+5400/-2400
	SG-72TG1D-XXX	+5400/-2400
	SG-66TG4D-XXX	+5400/-2400
	SG-78TG1D-XXX	+5400/-2400
	SG-48TT4D-XXX	+5400/-2400
	SG-54TT1D-XXX	+5400/-2400
	SG-54TT4D-XXX	+5400/-2400
	SG-72TT1D-XXX	+5400/-2400
	SG-66TT4D-XXX	+5400/-2400
	SG-78TT1D-XXX	+5400/-2400

Table 1 Test load of different models when installed with bolts using the four outer mounting holes

7.2.2 Installation with clamps

- If the Modules are installed with clamps, make sure there are four clamps at least on each Module. You can decide whether to use more clamps or not based on the local weather conditions (especially the wind and snow). The clamps should be symmetrically arranged, and different mounting positions of the clamps will affect the maximum load capacity of the Modules.
- The clamps shall not in contact with the front glass of the Modules or deform the frame of the Modules. The surface of the clamps in contact with the frame should be flat and smooth, otherwise it may damage the frame and cause Module breakage.
- Make sure the clamps will not cause shadows on the Modules and the drainage holes not be blocked by the clamps.
- The clamp length $L \geq 50\text{mm}$, thickness $t \geq 4\text{mm}$. The height H of the clamp should match the height of the frame to ensure a good fit between the clamp and the Module after installation. The clamp must maintain an overlap of at least 8mm but not more than 11mm with the frame of the Module, and the cross-section of the clamp can be changed as long as the Modules can be reliably and securely installed. The torque of the bolts for fixing the clamps should be decided based on the mechanical design of the bolts and the clamps used by the customer, such as torque for M8 bolt $16 \sim 20 \text{ N}\cdot\text{m}$.



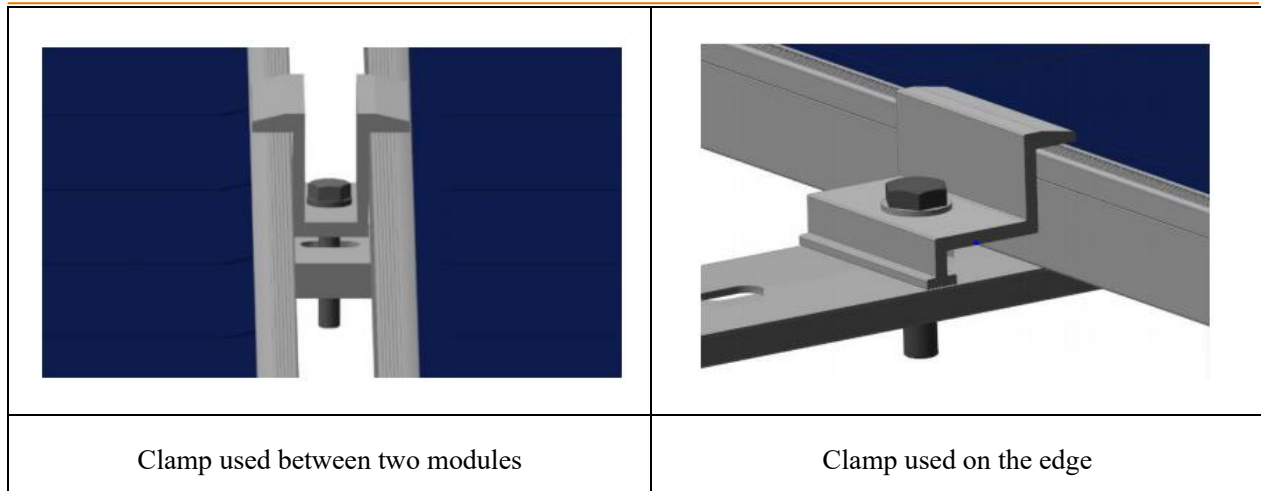


Fig. 13 Diagrammatic sketch of installation with clamps

- **Important note:** when there are mounting holes on the mounting rail, and the clamps are fixed by bolts with these holes, please fully consider the dimension tolerance of the Module in the datasheet when designing these mounting holes on the rail, otherwise the accumulated tolerance may cause misalignment between the clamps and the mounting holes on the rail, especially in the last half string. In addition to the design dimension, please fully consider the tolerance of the installation dimension to ensure proper matching of the Module dimension and the mounting holes on the rail. There are suggestions as follows:
 - Clamps with two or more sizes of K (see Fig. 13) can be prepared in the design stage. These clamps with different sizes of K can be used in an alternating or intermittent manner to eliminate the impact of the accumulated tolerance.
 - U-shaped hoops can be used to fix the clamps, in this way the mounting holes on the rail are no longer needed, as follows:

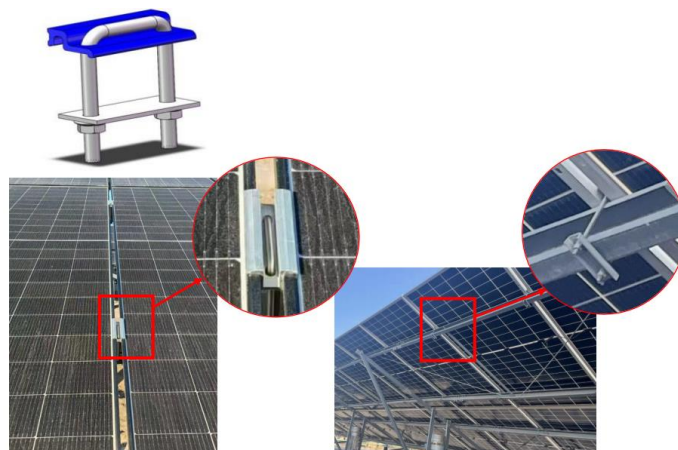


Fig. 14 Diagrammatic sketch of fixing the clamps with U-shaped hoops

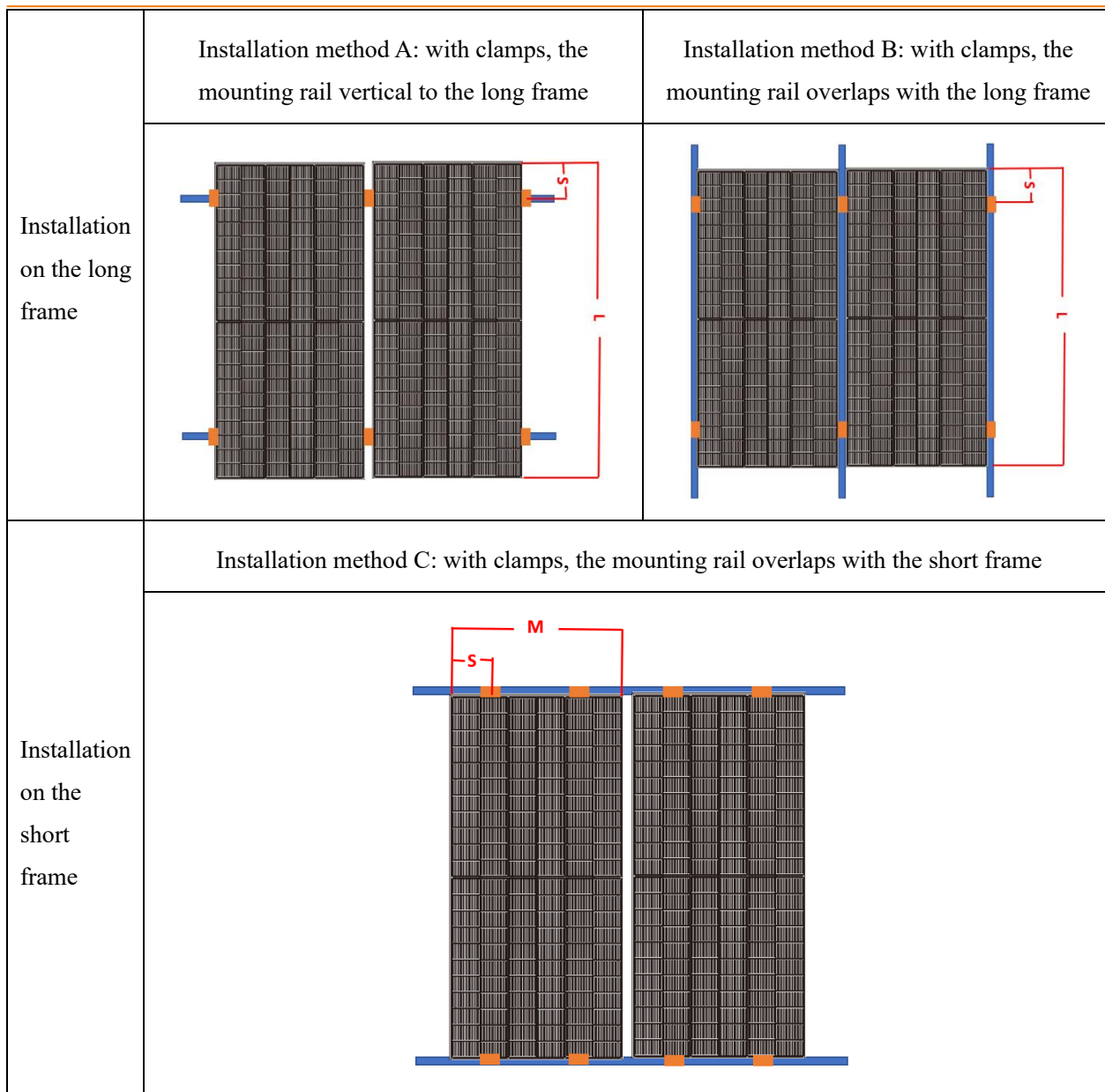


Fig. 15 Diagrammatic sketch of the installation position

Table 2 Test load of different models when installed on the long frame					
Module model		Installation method A		Installation method B	
		Location of the clamp S (mm)	Test load front/back (Pa)	Location of the clamp S (mm)	Test load front/back (Pa)
Anodized aluminum alloy framed	SG-48TG4D- XXX	400~500	+5400/-2400	400~500	+3600/-2400
	SG-54TG1D-	400~500	+5400/-2400	400~500	+3600/-2400

	XXX				
	SG-54TG4D-XXX	400~500	+5400/-2400	400~500	+3600/-2400
	SG-72TG1D-XXX	400~500	+5400/-2400	400~500	+3600/-2400
	SG-66TG4D-XXX	450~550	+5400/-2400	450~550	+3600/-2400
	SG-78TG1D-XXX	400~500	+5400/-2400	400~500	+3600/-2400
Composite material framed	SG-48TG4D-XXX	400~500	+5400/-2400	400~500	+3600/-2400
	SG-54TG1D-XXX	400~500	+5400/-2400	400~500	+3600/-2400
	SG-54TG4D-XXX	400~500	+5400/-2400	400~500	+3600/-2400
	SG-72TG1D-XXX	400~500	+5400/-2400	400~500	+3600/-2400
	SG-66TG4D-XXX	450~550	+5400/-2400	450~550	+3600/-2400
	SG-78TG1D-XXX	400~500	+5400/-2400	400~500	+3600/-2400
Anodized aluminum alloy framed	SG-48TT4D-XXX	400~500	+5400/-2400	400~500	+3600/-2400
	SG-54TT1D-XXX	400~500	+5400/-2400	400~500	+3600/-2400
	SG-54TT4D-XXX	400~500	+5400/-2400	400~500	+3600/-2400
	SG-72TT1D-	400~500	+5400/-2400	400~500	+3600/-2400

	XXX				
	SG-66TT4D-XXX	450~550	+5400/-2400	450~550	+3600/-2400
	SG-78TT1D-XXX	400~500	+5400/-2400	400~500	+3600/-2400
Composite material framed	SG-48TT4D-XXX	400~500	+5400/-2400	400~500	+3600/-2400
	SG-54TT1D-XXX	400~500	+5400/-2400	400~500	+3600/-2400
	SG-54TT4D-XXX	400~500	+5400/-2400	400~500	+3600/-2400
	SG-72TT1D-XXX	400~500	+5400/-2400	400~500	+3600/-2400
	SG-66TT4D-XXX	450~550	+5400/-2400	450~550	+3600/-2400
	SG-66TT4D-XXX (Dustproof)	450~550	+5400/-2400	450~550	+3600/-2400
	SG-78TT1D-XXX	400~500	+5400/-2400	400~500	+3600/-2400

Table 3 Test load of different models when installed on the short frame			
Module model		Installation method C	
		Location of the clamp S (mm)	Test load front/back (Pa)
Anodized aluminum alloy framed	SG-48TG4D-XXX	100~240	±1200
	SG-54TG1D-XXX	100~240	±1200

	SG-54TG4D-XXX	100~240	±1200
	SG-72TG1D-XXX	100~240	±1200
	SG-66TG4D-XXX	0~M/4	±1200
	SG-78TG1D-XXX	/	/
Composite material framed	SG-48TG4D-XXX	100~240	±1200
	SG-54TG1D-XXX	100~240	±1200
	SG-54TG4D-XXX	100~240	±1200
	SG-72TG1D-XXX	100~240	±1200
	SG-66TG4D-XXX	0~M/4	±1200
	SG-78TG1D-XXX	/	/
Anodized aluminum alloy framed	SG-48TT4D-XXX	100~240	±1200
	SG-54TT1D-XXX	100~240	±1200
	SG-54TT4D-XXX	100~240	±1200
	SG-72TT1D-XXX	100~240	±1200
	SG-66TT4D-XXX	0~M/4	±1200
	SG-78TT1D-XXX	/	/
Composite material framed	SG-48TT4D-XXX	100~240	±1200
	SG-54TT1D-XXX	100~240	±1200
	SG-54TT4D-XXX	100~240	±1200
	SG-72TT1D-XXX	100~240	±1200
	SG-66TT4D-XXX	0~M/4	±1200
	SG-66TT4D-XXX (Dustproof)	0~M/4	±1200

	SG-78TT1D-XXX	/	/
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8 Electrical Installation

8.1 Electrical Performance

8.1.1 The nominal values of the electrical parameters of the Modules such as I_{sc} , V_{oc} and P_{max} have an error of $\pm 3\%$ from the values measured under the standard test conditions. The standard test conditions are irradiance $1000W/m^2$, cell temperature $25^{\circ}C$, atmospheric mass AM1.5.

8.1.2 Normally, the current and voltage generated by the Modules may be higher than the values measured under the standard test conditions, therefore when preparing the PV system accessories related with the power output of the Modules and designing their parameters such as rated voltage, wire capacity and fuse capacity, please multiply the short-circuit current and open-circuit voltage by 1.25.

8.1.3 When the Modules are connected in a string, the final voltage is the sum of the voltage of an individual Module, and when the Modules are connected in parallel, the final current is the sum of the current of an individual Module.

8.1.4 Do not use different models of Modules in the same PV system. When the Modules are connected in series, the voltage of each string shall not exceed the maximum system voltage. Please refer to the local, regional or national regulations for details.

8.1.5 When the Modules are connected in parallel, the current output of the entire string is the sum of the current of each branch Module or string, and each string should be installed with a fuse. The maximum number of Modules to be connected in parallel is calculated as follows: maximum permissible current/(1.25*short-circuit current). Please refer to the local, regional or national regulations for details.

8.1.6 The number of Modules to be connected in series in a string shall be calculated in accordance with relevant regulations. See the following formula. Its open-circuit voltage under the expected local minimum temperature shall not exceed the maximum system voltage specified for the Modules (according to the IEC61730 safety test, the maximum system voltage of the Sungrow Renewables Modules is DC1500V) and the values required by other DC electrical components.

$$N \leq \frac{V_{dmax}}{V_{oc} \times [1 + (t - 25) \times K_v]}$$

$$\frac{V_{mpptmin}}{V_{pm} \times [1 + (t' - 25) \times K_v']}] \leq N \leq$$

$$\frac{V_{mpptmax}}{V_{pm} \times [1 + (t - 25) \times K_v']}$$

In which, K_v means temperature coefficient of V_{oc} of the Modules.

K_v' means temperature coefficient of voltage at maximum power of the Modules.

N means the number of modules to be connected in series, N should be an integer.

t means the lower operating temperature (°C) of the Modules.

t' means the upper operating temperature (°C) of the Modules.

V_{dcmax} means the maximum DC input voltage (V) of the inverters.

$V_{mpptmax}$ means the maximum MPPT voltage (V) of the inverters.

$V_{mpptmin}$ means the minimum MPPT voltage (V) of the inverters.

V_{oc} means the open circuit voltage (V) of the Modules.

V_{pm} means the voltage at maximum power (V) of the Modules.

8.1.7 The correction factor of the open-circuit voltage can be calculated as follows: $C_{Voc}=1-\beta_{Voc}*(25-T)$. T is the minimum temperature expected at the installation site and β (%/°C) is the temperature coefficient corresponding to the Voc of the Module (please refer to the Module datasheet).

8.1.8 If a reverse current exceeding the maximum fuse current of the Module is likely to pass through the Module, it must be protected by an overcurrent protection device of equivalent specification. If two or more strings of Modules are connected in parallel, each string shall have an overcurrent protection device.

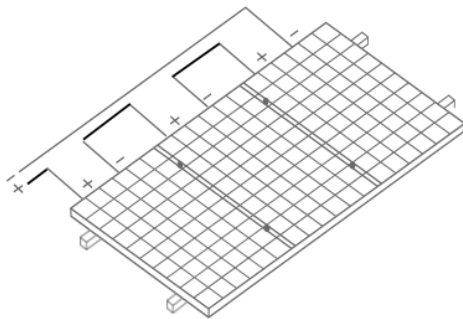


Fig. 16 Connection in series

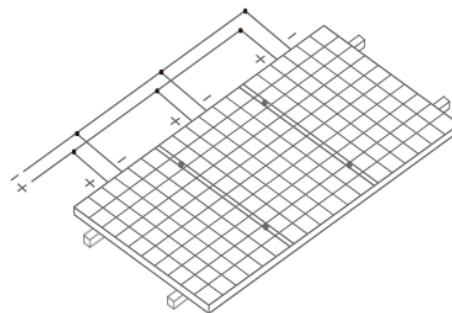


Fig. 17 Connection in parallel

8.2 Cables and Wires

8.2.1 The Modules are equipped with sealed junction boxes with a protection class of IP68, which protect the wires and connections from being affected by the environment and uninsulated energized parts. The junction boxes have connected cables and connectors with a protection class of IP68 for the Modules to be connected with each other. Each Module has two separate wires connected to the junction box, one positive and one negative. Insert the positive wire of one Module into the socket on the negative wire of another Module, in this way the two Modules will be connected in series.

8.2.2 The cables used for connecting the Modules shall allow the maximum short-circuit current of the Module, and be light-resistant cables specially designed for PV systems.

8.2.3 The minimum standard of the cables used for connecting the Modules:

Test standard	Diameter	Temperature
TÜV 2 Pfg 1169	4mm ²	-40°C~+90°C

8.2.4 When the cables are fixed on the brackets, avoid mechanical damage to the cables or Modules. Do not apply pressure to the cables.

8.2.5 Take proper measures to fix the cables and use light-resistant cable ties and clips. Although the cables are resistant to aging and water, they should be protected from direct sunlight and rainwater. It is recommended that the cables be laid in a suitable pipe or trough during installation.

8.2.6 The minimum bending radius of the cables should be 43mm.

8.3 Connectors and Bypass Diodes

8.3.1 Keep the connectors dry and clean, and make sure the connector nuts are tightened before connection. Do not connect the connectors if they are wet, dirty or otherwise. Do not expose them to direct sunlight or immerse them in water. Do not drop them on the ground or roof.

8.3.2 Incorrect connections may cause electric arc or shock. Make sure all electrical connections are secure and all connectors with locking are fully locked.

8.3.3 Do not expose the connectors to organic solvents or other corrosive materials, such as alcohol, gasoline, pesticides and herbicides. Sungrow Renewables shall not be liable for cracking of connectors arising therefrom.

8.3.4 The Sungrow Renewables Modules contain bypass diodes in the junction boxes. The bypass diodes are connected in parallel to the cell strings within the Module. When part of the Module is affected by hot spot, the diodes begin to operate, and the main current will not pass through the cells subject to the hot spot, thus limiting Module heating and power loss. Please note that the bypass diode is not an overcurrent protection device.

8.3.5 Incorrect connections between the Modules may damage the bypass diodes, cables and junction boxes. Connectors and bypass diodes from different manufacturers shall not be used together.

8.3.6 If there is a bypass diode failure or suspected failure, the installer or system maintainer should contact Sungrow Renewables. Do not open the junction box by yourself.

8.3.7 The following tables show the manufacturer and type of connectors and bypass diodes in the junction boxes used for the Sungrow Renewables Modules.

Module type	Manufacturer	Type
Single-glass series	Zerun Co., Ltd.	Z4S-abcd
	Jiangsu Haitian Microelectronics Corp.	PV-HT03x (x=0,1 or 2)
	Zhejiang Zhonghuan Sunter PV	PV-ZH202B

	Technology CO., Ltd.	
8.3.8 Dual-glass series	Zerun Co., Ltd.	Z4S-abcd
	Jiangsu Haitian Microelectronics Corp.	PV-HT03x (x=0,1or 2)
	Zhejiang Zhonghuan Sunter PV Technology CO., Ltd.	PV-ZH202B
	QC Solar (Suzhou) Corporation	QC4.10-cds

Table 4 Manufacturer and type of connectors

Module type	Manufacturer	Type
Single-glass series	Zerun Co., Ltd.	30SQ045/35SQ045/40SQ045
	Jiangsu Haitian Microelectronics Corp.	MK3045/ MK4045/ MK5045/MK6045
	Zhejiang Zhonghuan Sunter PV Technology CO., Ltd.	35SQ045/40SQ045
Dual-glass series	Zerun Co., Ltd.	30SQ045/35SQ045/40SQ045
	Jiangsu Haitian Microelectronics Corp.	MK3045/ MK4045/ MK5045/MK6045
	Zhejiang Zhonghuan Sunter PV Technology CO., Ltd.	35SQ045/40SQ045
	QC Solar (Suzhou) Corporation	QCMK4045/QCMK4045B/30SQ050A/ QCM4045/QCMK5045/40SQ045/ QCM5045/QCM5045B

Table 5 Manufacturer and type of bypass diodes

8.4 Wiring

Sungrow Renewables recommends the following wiring:

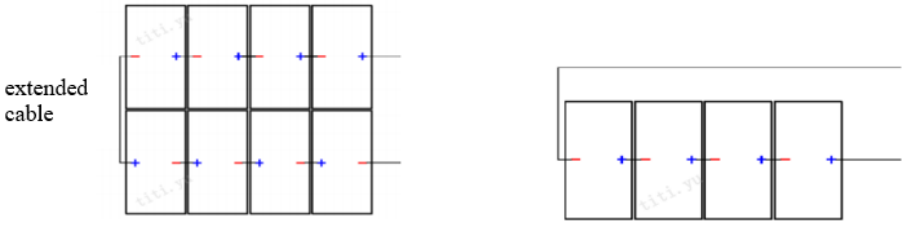
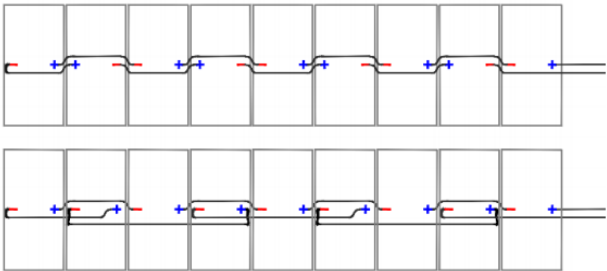
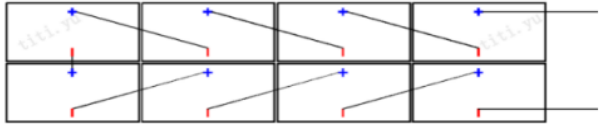
When the Modules are vertically installed: use standard cables	 Wiring of the Modules in two rows Wiring of the Modules in a single row
When the Modules are vertically installed: use customized cables	
When the Modules are horizontally installed: use customized cables	

Table 6 Diagrammatic sketch of wiring

8.5 Grounding

8.5.1 The Modules are designed with anodized, corrosion-resistant aluminum alloy frames, and the frames must be grounded for security and preventing damage from lightning and static electricity. Grounding is not required for composite material framed Modules.

8.5.2 Use suitable grounding conductors to connect the frames and all metal components for proper grounding. The grounding conductors or wires should be made of materials (such as copper) suitable for electrical conductors and comply with the local applicable laws, regulations and codes for electrical design and construction. The grounding conductors shall be reliably grounded through proper grounding electrodes.

8.5.3 The grounding device must be in full contact with the interior of the aluminum alloy, penetrating the oxide film on the surface of the frame.

8.5.4 Grounding between the Modules shall be confirmed by a qualified electrician and the grounding device shall be manufactured by a qualified electrical manufacturer.

8.5.5 There is a 4mm diameter grounding hole on the long frame near the edge on the back of the Module, which is marked with the typical grounding symbol ($\equiv$) according to IEC 61730-1:2023. This hole is only used

for grounding, not for installation. Bolts, flat washers, star washers, spring washers and nuts will be used for grounding, see Fig. 18. Please fasten the bolts for grounding, and do not drill holes in the frame, otherwise the warranty will be voided. Unused mounting holes in the frame may also be used for grounding.

8.5.6 The grounding device and materials must be provided by a qualified manufacturer. The bolts, nuts and washers should be of a size that matches the grounding hole. It is recommended to use M5 bolt kits for grounding, and the torque should be 4~8 N·m. The grounding wires are recommended to be 4-14mm² (AWG 6-12) copper core wires and should comply with local, national or international laws, regulations and standards.

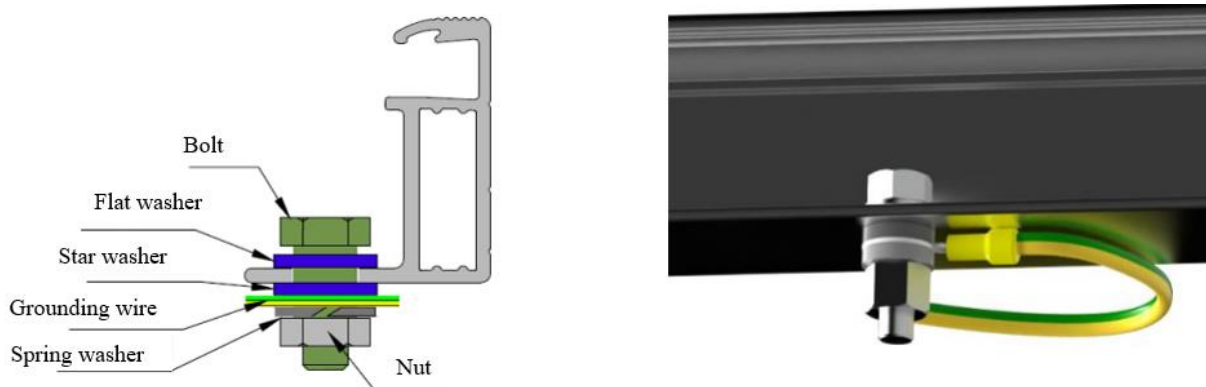


Fig. 18 Grounding with bolts

8.5.7 Sungrow Renewables allow to use other grounding methods, provided that:

- a) The installer shall be liable for using a proper grounding system.
- b) The above grounding system shall comply with the applicable electrical laws and regulations.
- c) The Sungrow Renewables Modules must be properly grounded.
- d) The grounding method will not have any impact on the power output of the Sungrow Renewables Modules and its warranty for the Modules.
- e) Sungrow Renewables shall not be liable for any faults or defects caused by the selected grounding method.

8.6 Electrical Data (STC&BNPI&aBSI)

MODULE TYPE/S	SG-54TG1D-435	SG-54TG1D-440	SG-48TG4D-440	SG-48TG4D-445	SG-48TG4D-450
STC					
Voc (with tolerance± 3%) [V]	39.38± 3%	39.58± 3%	34.67± 3%	34.85± 3%	35.03± 3%
Isc (with tolerance± 3%) [A]	13.97±3%	14.05±3%	15.95±3%	16.00±3%	16.05±3%

MODULE TYPE/S	SG-54TG1D-435	SG-54TG1D-440	SG-48TG4D-440	SG-48TG4D-445	SG-48TG4D-450
VPmax [V]	32.86	33.04	29.72	29.90	30.08
IPmax [A]	13.24	13.32	14.81	14.89	14.97
Pmax (with tolerance± 3%) [W]	435±3%	440±3%	440±3%	445±3%	450±3%
BNPI					
Voc (with tolerance± 3%) [V]	39.38± 3%	39.58± 3%	34.67± 3%	34.85± 3%	35.03± 3%
Isc (with tolerance± 3%) [A]	15.37±3%	15.46±3%	17.55±3%	17.60±3%	17.66±3%
VPmax [V]	32.86	33.04	29.72	29.90	30.08
IPmax [A]	14.56	14.65	16.29	16.38	16.47
Pmax (with tolerance± 3%) [W]	479±3%	484±3%	484± 3%	490± 3%	495± 3%
aBSI					
Isc (with tolerance± 3%) [A]	17.07±3%	17.17±3%	19.49± 3%	19.56± 3%	19.62± 3%

MODULE TYPE/S	SG-54TG4D-495	SG-54TG4D-500	SG-54TG4D-505	SG-78TG1D-635	SG-78TG1D-640
STC					
Voc (with tolerance± 3%) [V]	39.88± 3%	40.06± 3%	40.24± 3%	57.21 ± 3%	57.34 ± 3%
Isc (with tolerance± 3%) [A]	15.86±3%	15.89±3%	15.92±3%	13.92±3%	13.98±3%
VPmax [V]	33.45	33.7	33.94	47.86	48.02
IPmax [A]	14.8	14.84	14.88	13.27	13.33
Pmax (with tolerance± 3%) [W]	495±3%	500±3%	505±3%	635±3%	640±3%
BNPI					
Voc (with tolerance± 3%) [V]	39.88± 3%	40.06± 3%	40.24± 3%	57.21 ± 3%	57.34 ± 3%

MODULE TYPE/S	SG-54TG4D-495	SG-54TG4D-500	SG-54TG4D-505	SG-78TG1D-635	SG-78TG1D-640
Isc (with tolerance $\pm$ 3%) [A]	17.45 $\pm$ 3%	17.48 $\pm$ 3%	17.51 $\pm$ 3%	15.31 $\pm$ 3%	15.38 $\pm$ 3%
VPmax [V]	33.45	33.7	33.94	47.86	48.02
IPmax [A]	16.28	16.32	16.37	14.60	14.66
Pmax (with tolerance $\pm$ 3%) [W]	545 $\pm$ 3%	550 $\pm$ 3%	556 $\pm$ 3%	699 $\pm$ 3%	704 $\pm$ 3%
aBSI					
Isc (with tolerance $\pm$ 3%) [A]	19.38 $\pm$ 3%	19.42 $\pm$ 3%	19.46 $\pm$ 3%	17.01 $\pm$ 3%	17.09 $\pm$ 3%

MODULE TYPE/S	SG-48TT4D-435	SG-48TT4D-440	SG-48TT4D-445	SG-66TT4D-610	SG-66TT4D-615
STC					
Voc (with tolerance $\pm$ 3%) [V]	34.49 $\pm$ 3%	34.67 $\pm$ 3%	34.85 $\pm$ 3%	48.18 $\pm$ 3%	48.31 $\pm$ 3%
Isc (with tolerance $\pm$ 3%) [A]	15.90 $\pm$ 3%	15.95 $\pm$ 3%	16.00 $\pm$ 3%	16.14 $\pm$ 3%	16.21 $\pm$ 3%
VPmax [V]	29.54	29.72	29.90	40.07	40.23
IPmax [A]	14.73	14.81	14.89	15.23	15.29
Pmax (with tolerance $\pm$ 3%) [W]	435 $\pm$ 3%	440 $\pm$ 3%	445 $\pm$ 3%	610 $\pm$ 3%	615 $\pm$ 3%
BNPI					
Voc (with tolerance $\pm$ 3%) [V]	34.49 $\pm$ 3%	34.67 $\pm$ 3%	34.85 $\pm$ 3%	48.18 $\pm$ 3%	48.31 $\pm$ 3%
Isc (with tolerance $\pm$ 3%) [A]	17.49 $\pm$ 3%	17.55 $\pm$ 3%	17.60 $\pm$ 3%	17.75 $\pm$ 3%	17.83 $\pm$ 3%
VPmax [V]	29.54	29.72	29.90	40.07	40.23
IPmax [A]	16.20	16.29	16.38	16.75	16.82
Pmax (with tolerance $\pm$ 3%) [W]	479 $\pm$ 3%	484 $\pm$ 3%	490 $\pm$ 3%	671	677
aBSI					

MODULE TYPE/S	SG-48TT4D-435	SG-48TT4D-440	SG-48TT4D-445	SG-66TT4D-610	SG-66TT4D-615
Isc (with tolerance $\pm$ 3%) [A]	19.43 $\pm$ 3%	19.49 $\pm$ 3%	19.56 $\pm$ 3%	19.72 $\pm$ 3%	19.81 $\pm$ 3%

MODULE TYPE/S	SG-66TG4D-610	SG-66TG4D-615	SG-66TG4D-620	SG-72TG1D-585	SG-72TG1D-590
STC					
Voc (with tolerance $\pm$ 3%) [V]	49.00 $\pm$ 3%	49.30 $\pm$ 3%	49.60 $\pm$ 3%	52.70 $\pm$ 3%	52.90 $\pm$ 3%
Isc (with tolerance $\pm$ 3%) [A]	15.86 $\pm$ 3%	15.89 $\pm$ 3%	15.91 $\pm$ 3%	14.01 $\pm$ 3%	14.07 $\pm$ 3%
VPmax [V]	40.80	41.10	41.40	44.02	44.17
IPmax [A]	14.96	14.98	14.99	13.29	13.36
Pmax (with tolerance $\pm$ 3%) [W]	610 $\pm$ 3%	615 $\pm$ 3%	620 $\pm$ 3%	585 $\pm$ 3%	590 $\pm$ 3%
BNPI					
Voc (with tolerance $\pm$ 3%) [V]	49.00 $\pm$ 3%	49.30 $\pm$ 3%	49.60 $\pm$ 3%	52.70 $\pm$ 3%	52.90 $\pm$ 3%
Isc (with tolerance $\pm$ 3%) [A]	17.45 $\pm$ 3%	17.48 $\pm$ 3%	17.50 $\pm$ 3%	15.41 $\pm$ 3%	15.48 $\pm$ 3%
VPmax [V]	40.80	41.10	41.40	44.02	44.17
IPmax [A]	16.46	16.48	16.49	14.62	14.70
Pmax (with tolerance $\pm$ 3%) [W]	671 $\pm$ 3%	677 $\pm$ 3%	682 $\pm$ 3%	643 $\pm$ 3%	649 $\pm$ 3%
aBSI					
Isc (with tolerance $\pm$ 3%) [A]	19.38 $\pm$ 3%	19.42 $\pm$ 3%	19.45 $\pm$ 3%	17.12 $\pm$ 3%	17.20 $\pm$ 3%

8.6.1 The electrical data are within 3 percent of measured values at Standard Test Conditions of: 1000 W/m², 25°C cell temperature and solar spectral irradiance per IEC 60904-3 or irradiation of AM1.5 spectrum.

8.6.2 BNPI means electrical data measured under 1000W/m² on front, 135W/m² on back, irradiance with AM 1.5 spectrum and 25°C (77°F) ambient temperature.

8.6.3 aBSI means electrical data measured under 1000W/m² on front, 300W/m² on back, irradiance with AM

1.5 spectrum and 25°C (77°F) ambient temperature.

9 Maintenance and Care

The Modules need regular inspection and maintenance, especially within the warranty period. To make sure the Modules have optimal performance, Sungrow Renewables recommends the following maintenance measures.

9.1 Appearance Inspection

Please regularly check the Modules for any appearance defects, especially the followings:

- Anti-reflective films are applied on the Modules, so it is normal to find color differences when observing the Modules from different angles. If color difference is observed within a piece of cell, please contact Sungrow Renewables for further analysis.
- Check if there is glass damage.
- The surface of the Modules shall not come into contact with sharp objects
- The surface of the Modules shall not be covered by obstacles or foreign objects.
- Check if there is corrosion near the fingers of the cells. Such corrosion is caused usually because the encapsulating materials are damaged during installation or transportation, and there is water vapor permeates into the Modules. Check if the encapsulating materials are delaminated or have bubbles.
- Check if there is bulging or marks of heating or burning on the back sheet of the Modules.
- Check if the screws for fixing the Modules and the brackets are loose or damaged. If yes, adjust or repair them in time.

9.2 Inspection of Cables and Connectors

It is recommended that a preventive inspection be conducted every 6 months, focusing on the following items:

- Check the sealant of the junction boxes, and make sure there are no cracks or gaps.
- Check if the connectors are well sealed and if there is any loosening, deformation or corrosion.
- Check if the cables are securely connected and the Modules are properly grounded.
- Check if the cables are damaged by rodents or if there is any material aging.

When any defect is observed, please consult a service professional, and if repairs are required, please contact a service professional. During the repair, please cover the Modules with opaque materials to prevent electric shock, as the Modules exposed to the sunlight will generate high voltage.

9.3 Module Cleaning

Dust and dirt including industrial wastewater and bird droppings on the glass of the Modules will reduce the power output and possibly cause hot spot effect. The extent of the effect depends on the transparency of the dirt. A little dust on the glass will affect the intensity and uniformity of the sunlight received by the Modules, so the

Modules need to be regularly cleaned. The frequency of cleaning can be based on the rate of dirt accumulation, and the Modules installed in dusty environments need more cleaning. Modules installed without tilting (tilt angle is 0°) also need more cleaning, as these Modules cannot have “self-cleaning” as those installed at the tilt angle of 10° or greater.

9.3.1 Notice about cleaning

- Cleaning may cause damage to the Modules and other components or parts and increase the risk of electric shock.
- Broken or damaged Modules present a risk of electric shock due to leakage current, and wet Modules increase such risk. Therefore, please check whether there is any breakage or damage on the Modules and whether all the joints are securely connected.
- To minimize the risk of electric shock or burns, please clean the Modules in the early morning or at nightfall when there is little sunlight and the Modules are cooler, and make sure to disconnect the circuits before cleaning.
- Do not wash the back sheet of single-glass series. The back glass of dual-glass series can be cleaned when necessary, and the cleaning requirements are the same as those for the front glass.
- The cleaning personnel should wear protective equipment including insulated gloves, protective glasses, safety helmets and insulated shoes.
- When using a scaffold, make sure the scaffold is placed on a flat surface or there are anti-tipping measures. The cleaning personnel should wear a safety belt in accordance with the local regulations on construction.
- Do not stand on the Modules or brackets for cleaning.
- Before cleaning, check if there is any crack, damage or loose joint.
- Do not clean the Modules with damaged glass or exposed wires, otherwise it may cause electric shock.
- Do not wash the back sheet, cables and connectors of the Modules. Keep the connectors clean and dry and prevent electric shock and fire.
- Do not apply pressure on partial of the Module when cleaning, as it will deform the glass, damage the cells inside and reduce the service life of the Modules.
- Clean the snow on the Modules in time, as accumulation of snow and snow melting and freezing may damage the Modules, but do not clean the Modules under extreme weather conditions.
- Commercial glass cleaning agents can be used only if the Modules cannot be cleaned with water. Do not use cleaning agents containing acids and alkalis.
- Use a soft and clean cloth, sponge, or soft brush to clean the Modules, and make sure the cleaning

tools will not damage the glass, silicon, aluminum alloy, or steel.

- Make sure the difference between the water temperature and the Module temperature is between -5°C and 10°C when cleaning.
- Do not use vapor or corrosive chemicals to accelerate cleaning.
- Do not clean the Modules under meteorological conditions of Beaufort wind force scale greater than 4, heavy rain or snow.

9.3.2 Cleaning method

9.3.2.1 General cleaning steps

- Step 1: sweep

Use a dry cloth to remove dust and leaves on the surface of the Modules. If there are no other wastes on the Module surface and the Modules are already clean with this step, the following steps can be ignored.

- Step 2: scrap

If there are hard foreign objects such as soil, bird droppings and leaves closely attached to the surface of the Modules, use non-woven cloth/soft sponge/soft foam material or brush (with nylon thread in the diameter of 0.06-0.1mm is recommended) to clean the Modules. Do not scrap the Modules with hard objects or scrap areas where there is no hard foreign objects attached.

- Step 3: water cleaning

If there are staining substances such as bird droppings and plant sap on the surface of the Modules, or if the air is humid, making it difficult to remove the dust on the surface, the Modules may need to be cleaned with water. Spray cleaning water onto the contaminated area and use a soft brush to remove the wastes.

If there is an oily waste, you can spray the mixture of water and alcohol onto the contaminated area, wait for the solution to dissolve the waste, and then use a soft brush to clean it.

If the waste still cannot be removed, use commercial glass cleaning agents and non-woven cloth to clean it.

- Step 4: clean the snow

The Sungrow Renewables Modules can withstand higher pressure from snow. If you want to clean the snow, please use a brush and clean it gently.

9.3.2.2 Cleaning with high-pressure water

- Water quality: PH: 6-8, water hardness - calcium carbonate concentration: $\leq 600\text{mg/L}$. Soft water is recommended.

- The water pressure on the glass surface shall not exceed 700 kPa, and the Modules shall not be subjected to additional pressure.

9.3.2.3 Cleaning with compressed air

- Soft stains such as dust on the Modules can be cleaned with compressed air. This method can be used as long as the cleaning result is good.

9.3.2.4 Cleaning with robots

- If a cleaning robot is used for dry cleaning, the brushes should be made of soft plastics. Make sure the cleaning will not damage the glasses and frames, and the cleaning robot not be too heavy. Sungrow Renewables shall not be liable for damage of the Modules and power degradation due to improper use of the cleaning robot.