



PV Modules Operation and Maintenance Manual

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1 Significance of PV Modules Operation and Maintenance

1.1 Impact of Operation and Maintenance on PV Modules

The modules of PV power stations are directly in contact with solar radiation and the external environment, and there are risks of shielding, material aging, damage and corrosion that affect the reliability of the modules. As the core power generation unit that converts light directly into electricity, the normal operation of modules has a crucial impact on the power generation, stability and safety of the PV power station. Therefore, professional operation and maintenance, regular inspections are very important.

1.2 Basis for PV Modules Operation and Maintenance

The Installation Manual, the Limited Warranty, the parameter list of a module, the PV modules certification standard, and the relevant product certification standards like IEC61730, IEC61215 and 2004 UL1703 shall be observed; actually the certification which the relevant module passes at that time shall be based on; and the Technical Specification for Performance Inspection and Quality Assessment for PV Power Station Connected to Grid and the Working Regulations on Electrical Safety shall be followed.

2 Applicable Modules type

Applicable to Monofacial of back sheet products, Bifacial dual glass products.

3 Operation & Maintenance Modes

3.1 Visual Inspection and Replacement

- The modules must be inspected and maintained regularly, which is the responsibility of the users. The circuit breaker should be disconnected before the inspection. Do not touch the live part of the cable or connector. If the modules are damaged, such as broken glass, broken cables, and damaged junction boxes, it may cause functional and safety failures.
- If the module is damaged, replace the damaged module with a new module of the same type. If Ulica Solar has ceased production of modules of the same specification and model as the defective module, Please contact Ulica Solar's customer service team for alternative models of modules or solutions that meet buyer's module application to reduce power generation losses and safety hazards at the PV power stations.
- If the modules are observed having slight module color differences at different angles, this is a normal phenomenon for modules with anti-reflection coating technology.
- If the module is damaged (broken glass or scratches on the back sheet), it needs to be replaced.
- Whether the frame is twisted or deformed.
- No sharp objects are in contact with the PV module surfaces.
- The PV modules are not shaded by unwanted obstacles or foreign material.

- Check whether the back sheet is burnt or damaged.
- Check whether the fixing screws between the module and the bracket are loose or damaged, and adjust or repair them in time.
- Check whether the connector is dropped.
- Check the sealant of the junction box to ensure there are no cracks or gaps.
- Check all cables for rodent damage or material deterioration to verify the connections. In addition, cables should be protected from direct sunlight and kept away from areas with accumulated water.
- Check whether all string fuses in each non-grounded pole are working properly.
- Please cover the front surface of modules with an opaque material during repairing. Modules exposed to sunlight can generate high voltage, which is extremely dangerous.
- Ulica Solar PV modules are equipped with bypass diodes in the junction box to minimize module heating and current losses.
- Due to the operation of tracker or any other environmental forces, the secured cables may loosen. Please regularly inspect the cable fastenings to prevent the connectors from hanging due to cable loosening.
- Do not try to open the junction box to replace diodes, even if they fail.
- When performing special installations, it is necessary to wear cut-resistant gloves and other personal protective equipment.
- Before attempting to remove modules, be sure to isolate the impacted array string to prevent current generation.
- Use the relevant disconnect tool provided by the supplier to disconnect the connector of the affected module.
- Check the open-circuit voltage of the array string and verify that the open-circuit voltage of other strings connected in parallel are within a range of 10V difference.
- Turn the circuit breaker on again after checking.

3.2 Cleaning of PV Array

This Manual covers the requirements for the cleaning procedures of Ulica Solar PV modules. Professional installers should read these guidelines carefully and strictly follow these instructions. Failure to follow these instructions may result in death, injury, or property damage. Damages induced by inappropriate cleaning procedures will void Ulica Solar Limited Warranty.

3.2.1 Notes for Cleaning of PV Modules

- Cracked or broken modules represent an electric shock hazard due to leakage currents, and the risk of shock is increased when modules are wet. Before cleaning, thoroughly inspect modules for cracks, damage, and loose connections.
- Please make sure that the array has been disconnected from other active components before starting the cleaning. Otherwise contact with exposed parts of live parts may cause injury.

- Do not clean the modules during the hottest time of the day to avoid thermal stress on the modules.
- No cleaning shall be allowed when the ambient temperature is lower than 5°C so as to prevent the glass of the PV module from being frost-cracked. To clean a PV module with liquid whose temperature greatly differs from that of the module is not recommended.
- Ulica Solar recommends to clean PV modules during early morning or late afternoon hours when solar irradiation is low (the irradiance is lower than 200W/m²) and the modules are cooler, especially in regions with hot temperatures.
- Do not clean modules under the weather conditions of wind more than 4 class (in Beaufort scale), heavy rain or heavy snow.
- For modules that are installed horizontally (0°~5° tilt angle), it is easy to accumulate dust or other contaminants on the surface of the module, they should be cleaned more frequently, as they do not have "self-cleaning" function as those installed at 10° or larger tilt angles. However, frequent cleaning will lead to the destruction of the AR film (anti-reflective film) on the glass surface of the module, resulting in a decrease in the power of the module (about 2%). During operation & maintenance, select as appropriate.
- Before cleaning, make sure to wear personal protective equipment, such as insulated protective gloves, protective glasses, hard hats, safety insulated shoes, etc.
- Do not stand on the modules or trackers for cleaning work.
- If it is not very visually disturbing or a safety risk, it is not recommended to clean the back of the module and special attention should be paid to the cables and electrical connections when cleaning the back side. Among them, when the back is considered necessary to clean. Monofacial or back sheet products: Since the backsheet is a soft composite material, heavy pressure is prohibited. When cleaning the backsheet to prevent the backsheet from being damaged and the cell from cracking. Use a soft, clean cloth, sponge or soft-bristled brush to gently wipe the backsheet to remove stains. If there are stains that are difficult to clean, it is recommended to use a cleaning agent. Bifacial dual glass products: To avoid any sharp objects that may cause damage or penetrate the base material. The other cleaning requirements are the same as the front-side.
- Cleaning activities create risk of damaging the modules and array components, as well as increasing the potential electric shock hazard.
- Do not immerse the module, partially or totally, in water or any other cleaning solutions.
- No tool or material which may cause scratch to the surface of a module shall be used. Use a dry or wet, soft and clean cloth, sponge, or soft bristled brush to wipe the PV module. Please make sure that the cleaning tools do not wear out glass, EPDM, silicon, aluminum alloys or steel.
- If there is greasy dirt or other substances which are difficult to clean, conventional household glass cleaning agents can be used. Pay attention not to use alkaline and strong acidic solvents, including hydrofluoric acid, alkali, acetone. For example, weak acids such as oxalic acid will cause patterns on the glass surface, which will not affect the power

output, but will affect the appearance, please choose carefully. For more information, Please connect Ulica Solar's customer service team.

- Do not use such as lubricants and organic solvents to clean the connectors.
- When there is a hard foreign matter on a PV module, it shall be removed with a yarn ball with medium hardness. And for scraping, the use of a highly-hard device shall be prohibited, to avoid scratching or damaging the glass surface.
- When the snow on the surface of a module is being removed, Please remove the snow on the module in time to avoid damage to the module caused by long-term accumulation of snow and melting and icing. However, refrain from cleaning the Modules in extreme weather conditions. Among them, use a mop or soft-bristled brush to gently remove all snow from the PV modules. It is strictly forbidden to forcibly clean frost and frozen snow to prevent damage to the glass on the surface of the module.
- The running water shall not scatter to any cable or the back of the module, a connector shall keep clean and dry to prevent electric shock and fire risk.
- Do not use steam cleaner.

3.2.2 Cleaning Methods

Methods A: Compressed water

Requirement for water quality:

- ①PH:6~8; ②Water hardness-Calcium carbonate concentration : ≤ 600 mg/L; ③Recommend to use soft water to wash; ④The recommended maximum water pressure is 4MPa (40 bar).

Method B: Compressed air

Ulica Solar recommends using this method to clean the soft dirt (like 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.
- Please make sure that any brushes or agitating tools are constructed with non-conductive materials to minimize 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.

Method D: Cleaning robot

If a cleaning robot is used for dry cleaning, the brush material is required to be soft plastic material, and the glass surface and aluminum alloy frame of the module will not be scratched during the cleaning process and after cleaning. The weight of the cleaning robot should not be too large. If the cleaning robot is improperly used, and the resulting module damage and power degradation are not covered by Ulica Solar's warranty.

3.2.3 Inspection over PV Module after Cleaning

- The overall appearance of the module shall keep clean and bright, without any dirt, through visual inspection.
- A sampling inspection shall be done to confirm whether there is any dust retained on the surface of the module.
- The surface shall be touched by hand slightly to confirm whether there is any foreign matter untreated.
- Whether the cell module is completely clean shall be judged on the basis of the generating capacity.
- There shall be no obvious scratch on the surface of the cell module.
- There shall be no man-made fracture phenomena on the surface of the module.
- Whether the rack of the module is inclined or bent shall be checked after cleaning.
- Whether the road in the PV array area is level shall be checked.
- Whether any terminal of the cell module falls off shall be inspected.
- After the PV module is cleaned, the written record about the cleaning of the PV module shall be made.

3.3 Removal of Vegetation in PV Array Area

This manual contains recommendations for weeding operation and maintenance of photovoltaic power station. The following measures can be taken to a certain extent to avoid and prevent the problem of module damage caused by stone splashing during weeding. System users and professional operation and maintenance personnel should read carefully. Limited Warranty will be invalid if the module or glass is damaged by any external force.

3.3.1 Matters to Be Noted During Removal of Vegetation in PV Array Area

- When the height of vegetation does not affect the normal operation and maintenance of the module, you can choose not to do weeding.
- The use of scythe manually instead of weeding machine weeding, or the use of professional weeding equipment with protective devices can reduce the probability of stone splash to a certain extent.
- During the removal of the vegetation in the PV area, the Working Regulations on Electrical Safety as well as the provisions and the systems of the provincial grid company, concerning safe production, shall be observed, so as to ensure personal safety and the safety of the PV module system and protect the environment.
- When a vegetation inhibitor is sprayed, this drug shall employ any component which may not corrode or oxidize the module system.
- Do not clean vegetation which may cover the module under the weather conditions of wind more than 4 class (in Beaufort scale), heavy rain or heavy snow.
- The removed vegetation shall be taken out of the PV array area for treatment.

3.3.2 Inspection after Removal of Vegetation

- It shall be confirmed that the light receiving face of the module is not covered by vegetation, through visual inspection.

- The site where removal is done shall keep clean and the PV module shall have no scratch.
- After the vegetation in the PV array area is removed, the written record about the cleaning of the PV module shall be finished.

3.4 Power Plant Operation and Maintenance Process & Operating Standards

As shown in Schedule 1

3.5 Trouble Shooting

- If your PV system does not work normally after installation, please inform your installer immediately. It is recommended to perform preventive inspections every six months, and do not change the components of the modules without authorization.
- If electrical or mechanical performance inspection or maintenance is required, they should be operated by qualified professionals to avoid any electric shock or personal injury.

4 Reporting Technical Issues and Claims

- Contact your installer.
- Please connect Ulica Solar's customer service team at sales@ulsolar.com.cn.
- For module specifications or datasheets, please download from: <http://www.ulicasolar.com>.

5 Conclusion

The Manual serves as a guide for the management and operation of the PV power station. In order to ensure the safe operation of the PV power station, the effective time of the PV power station is ensured to maximize the power generation and the standard requirements for the daily work of the operation and maintenance personnel through management and technical means. Ulica Solar will continue to research and monitor the development of new products and technologies, and update the Manual when appropriate.

Schedule 1:

Serial number	Maintenance content		Circle time	Requirements
1	PV Modules	Module surface cleaning	3 times/year	After just cleaning, the surface of the module should be visually free of stains and dirt
		Module connections	4 times/year	The connector is plugged in place, no deformation, neat wiring and binding, and no exposure to the sun
		Module grounding	4 times/year	There are yellow-green grounding wires between the module arrays, which are connected and fastened without falling off
		Module generation current	4 times/year	Check the input current of each PV module string connected to the same equipment, and the deviation should not exceed 5% under the condition that the orientation and solar radiation intensity are basically the same
		The temperature at which the module generates electricity	4 times/year	Check the temperature of the PV module with infrared thermal detector , and the temperature difference on the outer surface of the same PV module (the area directly above the cell) should be less than 20°C
		Module fixation	1 times/year	There is no missing fixed briquetting of PV modules, and the bolt and bracket are firmly and reliably connected
2	Module support brackets	Bracket appearance	1 times/year	The aluminum alloy bracket has no deformation and no corrosion
		Bracket fixation	1 times/year	The connection between the brackets is firm
		The bracket is grounded	1 times/year	The connection between the bracket and the grounding system should be reliable
3	AC combiner box and low-voltage power distribution equipment	Cabinet condition	4 times/year	The box door opens and closes flexibly, there is no deformation, tilt and rust, there is no water leakage in the box, and the anti-mud blocking is intact
		Power distribution equipment	4 times/year	Visually inspect the circuit breaker, the lightning arrester is in normal condition and the appearance is intact; The test closure is normal

Serial number	Maintenance content		Circle time	Requirements
3	AC combiner box and low-voltage power distribution equipment	Distribution equipment temperature	4 times/year	Use an infrared thermal detector to check the connection of the current terminal, the circuit breaker body, the branch fuse holder, and the temperature of the fuse body does not exceed 75°C
		Identification of power distribution equipment	4 times/year	Check that the identification device of the power distribution equipment indicating the number, name or operation position of the controlled equipment shall be complete, and the number shall be clear and neat
		Device monitoring	4 times/year	Check the communication status of the device monitoring, and check that the current and voltage acquisition data are correct
		grounding	4 times/year	The connection of the grounding system is reliable
4	PV inverters	Inverter appearance	4 times/year	Visually inspect the screws for no rust and no signs of overheating on the connecting terminals
		Inverter connection	4 times/year	The connecting wire is clearly marked, and the wiring is firm and reliable, and there is no loosening
		Inverter communication	4 times/year	Check the communication function of each inverter one by one, and communicate smoothly with the host computer without interruption
		Inverter operating data	4 times/year	Check that the output voltage, current, and power are collected correctly, and that the function indication is correct
		Comparison of inverter operation	4 times/year	There is no significant difference in inverter, string current, power generation, and power comparison in the same area
		The inverter is grounded	4 times/year	The connection of the grounding system is reliable
5	Power cables	Cable appearance	4 times/year	The cover plate of the cable tray, cable trench or cable well should be intact, the inner bracket should be firm, there should be no rust, no stagnant water, the lead package of the cable shall not swell, and the sheath of the cable should not crack or break

Serial number	Maintenance content		Circle time	Requirements
5	Power cables	Cable temperature	4 times/year	For multiple cables laid in parallel, the current distribution and the temperature of the cable sheath should be checked to prevent the cable from being damaged by overheating
		The cable tray is grounded	4 times/year	The connection of the grounding system is reliable
6	Step-up transformers	Transformer temperature control	4 times/year	Check the temperature control system of the transformer, the temperature indication does not exceed 125°C
		Transformer wiring	4 times/year	Use an infrared thermal detector to check the temperature rise of the terminal block and switch body, and the local temperature does not exceed 90°C
		Transformer lightning protection	4 times/year	Check whether the lightning arrester indication is normal
		Transformer grounding	4 times/year	The connection of the grounding system is reliable
7	High-voltage power distribution equipment	Operation of the equipment	4 times/year	Visually check the working status of each power distribution equipment, and the operation indicator is normal
		Metering equipment	4 times/year	Visually inspect the lead seals of the transformer, meter and terminal panel in the photovoltaic metering cabinet in good condition
		Equipment Protectors	4 times/year	Check the running status of the relay device, read the operating data, and there is no abnormality
		AC and DC screen operation	4 times/year	Check the operating parameters of the AC and DC screens, and they work normally
		Power distribution cabinets and communication equipment	4 times/year	Check the communication cabinet, high-voltage distribution cabinet, secondary equipment cabinet, DC screen work indication normal equipment
8	Data monitoring	Equipped with data collection, monitoring devices, security equipment	4 times/year	Check that there are no abnormalities in the running status and data of the configured device
		Power generation data report	1st/day/month	Mobile APP remote monitoring, if there is an abnormality, you need to submit exception handling measures

Serial number	Maintenance content		Circle time	Requirements
8	Data monitoring	Communications, communication lines and transmission networks	4 times/year	There is no abnormality in the line, operation status and operation data transmission in the station
9	Other daily operation and maintenance	The power sector requires peak shaving and shutdown, etc	according to notice	Report to the relevant person in charge first, and then complete the relevant power station operation according to the instructions
		Roofing companies request suspension of operations, etc	according to notice	Report to the relevant person in charge of the company first, and then complete the relevant power station operation according to the instructions
		Abnormal suspension of operations, etc	Depending on what happens	Report to the relevant person in charge of the company first, and then complete the relevant power station operation according to the instructions
		Labor construction	all year round	According to the construction of 2% of the number of components of a single power station, a technical transformation plan is proposed for the excess part
		Meter reading settlement	1 time/month	According to the time node, report to the relevant person in charge of the company after the on-site meter reading