



Instruction for Use of AUO's Photovoltaic Modules

1. Introduction

Please read all the instructions in this document carefully before installing, connecting, or handling the photovoltaic module. The recommendations given for one photovoltaic module may be extended to more than one. AUO will not be held responsible in the event of loss, breakage, damage or additional cost, due to mishandling of the product by personnel unaffiliated with AUO.

1.1 General instruction

AUO provides high quality modules using high efficiency crystalline silicon cells to turn solar radiation energy into direct current electric power. The cells and connection ribbons are laminated using EVA (ethylene-vinyl acetate) encapsulation, in an assembly formed by tempered glass at its front and plastic polymer (PVF) at the rear. The encapsulated laminate provides resistance against environmental agents and provides electrical insulation. The laminate fits into an anodized aluminum structure. The IP-65 grade junction boxes are made from high temperature resistant plastics and contain junctions, connection junctions, and protection diodes (by-pass diodes). The frame has several fastening holes for securing the module to the support structure and its grounding. Figure 1 schematically shows a section of a photovoltaic module.

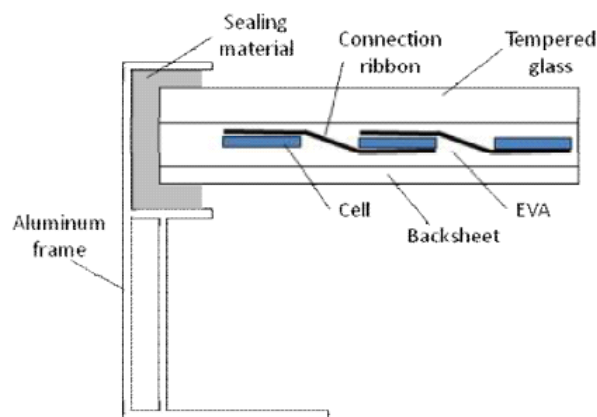


Figure 1 Schematic drawing of a photovoltaic module section

The electrical ratings of AUO's modules are listed in Table 1, however the ratings can be different when using cells with different efficiency. The electrical rating is listed on the label at the rear of the module. The electrical characteristics are within -0/+3 percent of the indicated values of I_{sc} , V_{oc} , and P_{max} under standard test conditions (STC) which correspond to a 1000 W/m² irradiance, AM1.5 spectrum and 25°C cell temperature. However, the modules' actual



working conditions, once installed, may be very different to laboratory conditions and, therefore, it is advisable to consider variations that may occur in order to carry out the pertinent corrections in calculations.

Table 1 Electrical Rating Table

Module Type	Pmax [W]	Voc [V]	Isc [A]	Vpm [V]	Ipm [A]
PM220P00_210 PM240P00_210	210	36.50	7.70	29.58	7.12
PM220P00_215 PM240P00_215	215	36.60	7.77	29.91	7.20
PM220P00_220 PM240P00_220	220	36.90	7.85	30.20	7.28
PM220P00_225 PM240P00_225	225	37.00	7.89	30.50	7.37
PM220P00_230 PM240P00_230	230	37.32	8.00	30.84	7.48
PM220P00_235 PM240P00_235	235	37.50	8.02	31.14	7.55
PM220P00_240 PM240P00_240	240	37.68	8.08	31.44	7.63
PM220P00_245 PM240P00_210	245	37.86	8.14	31.74	7.71
PM220P00_250 PM240P00_250	250	38.04	8.21	32.04	7.80

1.2 Performance of PV modules

A photovoltaic module generated current is proportional to the intensity of solar radiation, the voltage varies with cell temperatures. The variation in the electrical magnitudes of the modules with temperature is as follows:

- The voltage drops at a rate of 2.08 mV/°C for each cell stringed in the module at a temperature near 25° C.
- The current increases at the rate of 0.07%/°K of cell area at a temperature near 25° C.

Note that the cell temperature is usually higher than ambient temperature when it is exposed to sunlight. The increase in the cell's temperature compared to the air temperature depends on its characteristics and the actual characteristics of the module itself.

To summarize, depending on solar radiation, the temperature of the cells and of the equipment to which connected, a photovoltaic module will generate a certain current at a certain working voltage, the product of which will determine the power generated by the module.

Under normal conditions, a photovoltaic module is likely to experience conditions that produce more current and/or voltage than reported at standard test conditions. Accordingly, the values of I_{sc} and V_{oc} marked on this module should be multiplied by a factor of 1.25 when determining component voltage ratings, conductor current ratings, fuse sizes, and size of controls connected to the PV output. Refer to Sec. 690-8 of the National Electric Code for an additional multiplying factor of 125 percent (80 percent of rating) which may be applicable.

2. Bypass Diodes and Junction Box

The shading of a cell may give rise to a reverse voltage therein. This cell would therefore consume a portion of the power generated by the remainder in series, and an unwanted heating of the shaded cell would occur. This effect is called ‘hot spot’ effect. In an extreme case, the cell could break due to over-heating.

The use of bypass diodes reduces the risk of the shaded cells being heated, by limiting the current which runs through them and thus preventing breakage. In general, modules with 20 series cells are supplied with protection diodes which are located in the junction boxes as can be seen in the schematic included in the following section.

The module junction boxes are located at the rear of each module. They are manufactured to be weather resistant, and water-tight, with IP-65 grade.

The connection polarity must be correct for module operation. The junction box covers are marked with a drawing. They are opened by inserting a standard 3mm to 5mm (.125” – 2”) screwdriver into the destined pocket at the snap arm of the lid-front part and by now the lid can pried open. Thereby the snap arm will be unlocked and the lid can be lifted to unclose. To close, the lid backside will be hooked in the housing and closed through snapping of the lid front side with the housing-lower part.

Junction boxes must not be subject to any type of pressure when installing the module in a support structure. No item thereof should touch the junction box. Junction boxes are similar in modules of the same nominal voltage.

The cable used in this junction box with conductor section area 4mm^2 . Both the plus and minus cables are black. Application temperature range is from -40°C to 110°C . The minimum bending radius is 34mm. Insulation material used for internal wiring must have a temperature rating of min. 90°C according to IEC 60189.



3. Grounding

AUO's modules have a grounding hole on the frame's side marked with the symbol for inserting the ground contact. The grounding screw, bolt or other parts are separately used from the mounting parts of the module. Two ways are suggested, the one with grounding clip is



certified by UL according to UL1703 and IEC61730, and the grounding screw method is certified by TUV according to IEC61730.

3.1 Grounding Clip

A grounding clip, such as Tyco's Product Base Part Number 1954381, can be used for grounding connection. The grounding clip must be placed onto the frame so that the screw straddles the pre-drilled hole. It is recommended that the screw be tightened to a torque of 2.3 and 2.8 Nm [20 and 25 in.-lbs]. The head of the screw must be flush with the base and the base must be flush with the frame. Refer to Figure 2.

To place the wire, the wire must be bottomed in the wire slot (wire slot will cause the wire will form a slight curve). Refer to Figure 2. The grounding clip accepts solid uninsulated copper wire sizes 10 or 12 AWG. The wire must not be nicked, cut, or scraped. There is no preparation required. Then the slider must be engaged (slider covers the base) to terminate the wire. Refer to Figure 2.

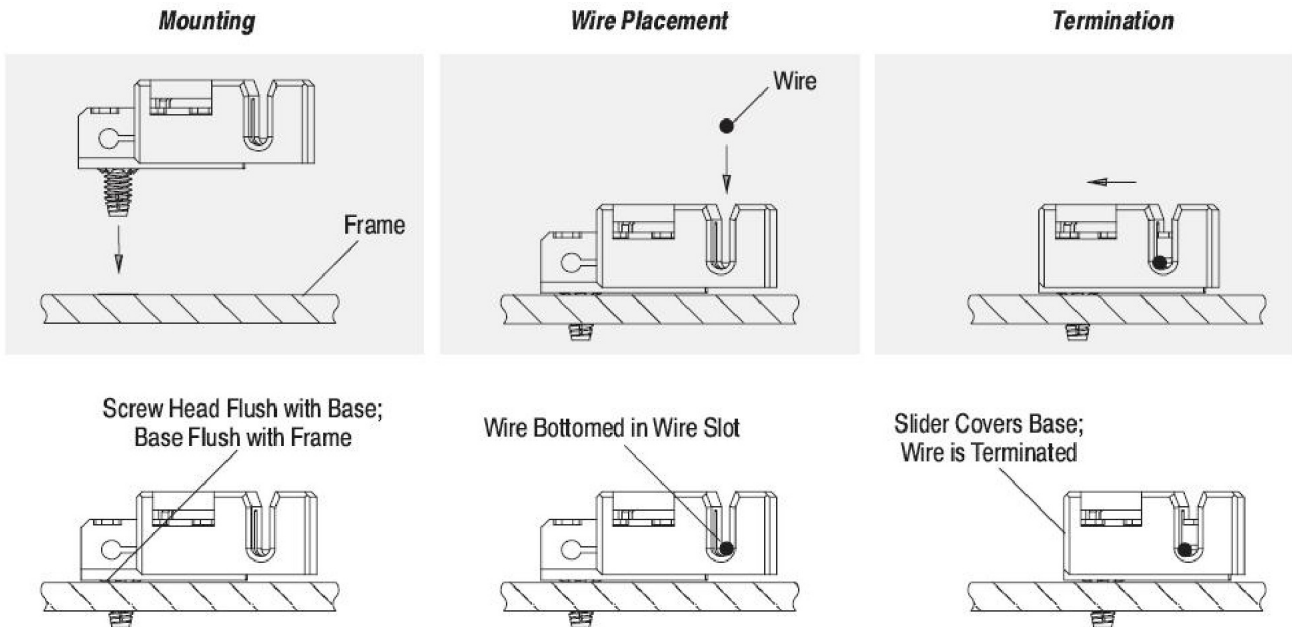


Figure 2 Grounding Clip Instruction

3.2 Grounding Screw

The suggested connection is shown in Figure 3. Note that AUO's frame is fully protected by anodizing, including the holes on the frame. Please make sure the grounding screw removes the anodizing on the surface of the grounding holes, or scratch off the anodizing before grounding connection. If the support structure is a conductor, contact between the module's frame and the structure must be ensured during the assembly of the modules. In that case, the structure must be grounded in accordance with current regulations in force. Should the support structure be a non conductor, a cable must be connected by means of a suitable fastening



system. The fastening system will be joined to a cable with a minimum 2.5mm^2 cross section, together with all the ground conductors from each module. It is recommended that connection be made to a grounding junction or strip, so that the removal of one of the panels does not interrupt the ground connection of the remaining modules.

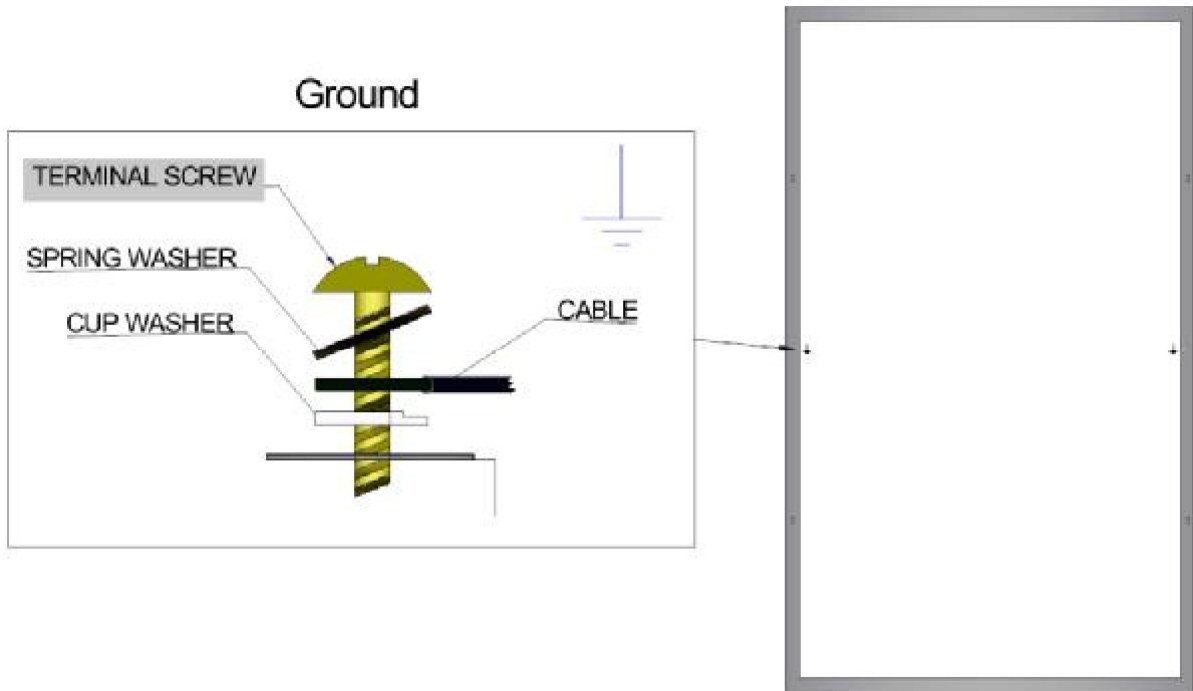


Figure 3 Suggestion of grounding connection

Devices listed and identified for grounding metallic frames of PV modules are permitted to ground the exposed metallic frames of the module to grounded mounting structures. Per NEC 250.136, electrical equipment secured to and in electrical contact with a metal rack or structure provided for its support and grounded by one of the means indicated in 250.134 shall be considered effectively grounded.

4. Mounting

For a non-integral module or panel, the assembly is to be mounted over a fire resistant roof-covering rated for the application. Modules may be mounted at any angle, from horizontal to vertical. Class C fire rating is maintained at a slope less than 5 in/ft (127mm/305mm)

The frame of the module must be connected with the substructure rails (mounting strips) by at least four points in the mounting area. Figure 4 shows the suggested installation and the mounting area is shown in Figure 5. Under no circumstances may the short frame edges be used for anchoring the module.



AUO recommends assembly on the support structure using the pertinent holes and specific nuts and bolts. The screws should be tightened up to 5.5 Nm (4.1 lb-ft). The module's frame must not be drilled nor put under pressure with other securing systems.

The supporting frames should be mounted in the suggested mounting area as below:

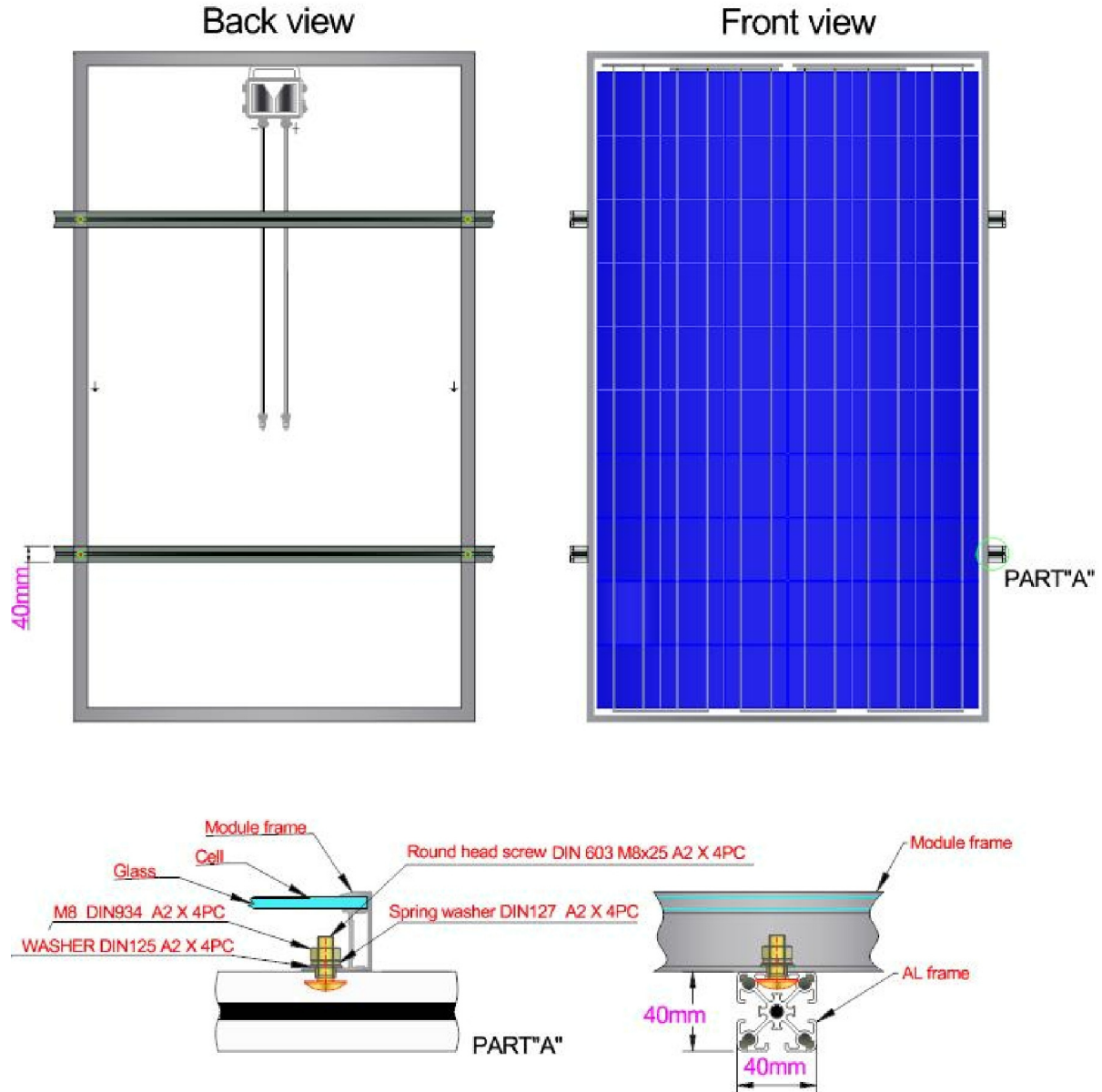
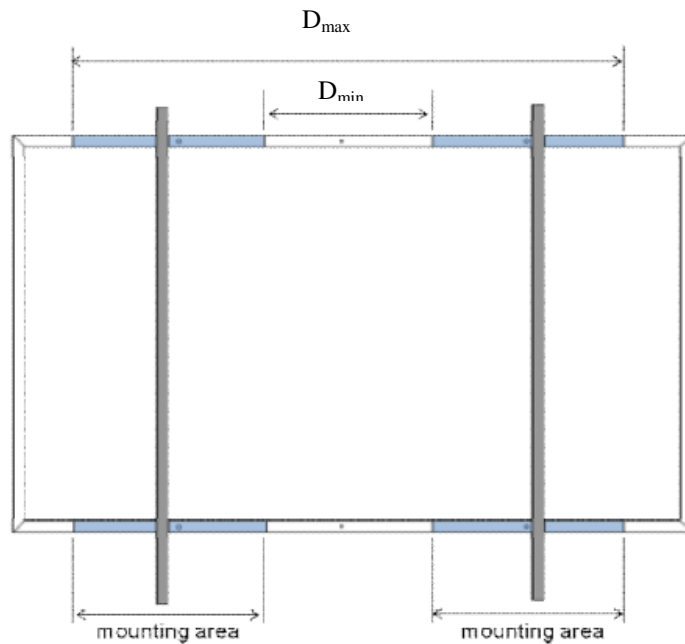


Figure 4 Suggested installation



Module Type	L (mm)	W (mm)	D _{min} (mm)	D _{max} (mm)
PM220P00_XXX PM240P00_XXX	1668	1000	550	1100

Note: XXX = 210 . 215 . 220 . 225 . 230 . 235 , 240 ,245 ,245 ,250

Figure 5 Mounting strips and mounting area

5. Installation Recommendations

Please note the following instructions:

- Ensure correct orientation of the module. The module should face southwards in the northern hemisphere and northwards in the southern hemisphere.
- The module must be installed so that air can freely circulate around it. The cells' working temperature will thus be reduced and, consequently, the module's performance will be enhanced.
- The cross section of the conductors used must ensure that the voltage drop in the installation does not exceed 2% of its nominal voltage.
- AUO modules are supplied with or without cables, according to the order placed. Should they be supplied without cables, it is recommended that cables with cross sections between 4 and 10 mm² be used. The use of cables formed by flexible Cu conductors, cross linked polyethylene insulated and with a polyvinyl chloride coat or similar, which allow easy handling while providing high performances against overloads and short-circuits is recommended. They must not be flame nor fire propagating and they must be low corrosive



gas emitters and acid and alkali resistant.

- The back of the module shall not be exposed to direct sunlight.

6. Warnings

- The modules should be installed and handled by qualified persons only.
- Do not climb up or walk on the module. Do not drop the module or throw objects onto it.
- Use the module only for the purpose to which it is aimed. Do not dismantle the module or remove any part, label, or piece installed by the manufacturer, including protection diodes, without the manufacturer's authorization.
- Do not concentrate sunlight or other artificial light sources onto the module.
- A photovoltaic module generates electricity when exposed to sunlight or other light sources. Totally cover the module's surface with an opaque material during installation, removal or handling.
- Use tools duly coated with insulating material during work with the module.
- Always work under dry conditions, both for the module and tools.
- Do not install the module where there may be flammable gases or vapors, since sparks may be produced.
- Avoid electric discharges when installing, wiring, starting up or carrying out maintenance work on the module.
- Do not touch the junctions while the module is exposed to light. Provide the installation with suitable protection devices to prevent a discharge of 30 or more direct current volts occurring on any person.

When modules are series connected, voltages are added. When parallel, the current is added. If batteries are used with the modules, follow all the recommendations regarding safety indicated by the battery manufacturer. Therefore, a system formed by photovoltaic modules may produce high voltages and currents, which implies an added hazard.

7. Limit of Connection

AUO's photovoltaic modules are made to withstand high voltages. The IEC 61730 certificate of these modules guarantees their insulation up to a DC voltage of 1000 V. (IEC Standard). Therefore, modules may be series connected until that voltage is reached.

You can use as many parallel modules as the load regulator, frequency variator or the pertinent equipment to which the modules are connected will accept. However, a cable with a



suitable cross section must be used for conducting the sum of the currents as generated by the modules. A series protection fuse of 15A is recommended for each string when module strings are parallel connected.

In any event, the conductor to be used will never have a cross section less than 4 mm^2 , and the cross section recommended is 6 mm^2 . Should a greater cross section be required carrying power to the equipment in question, external connection boxes will be used enabling greater cable cross sections to be acquired for long distance stretches.

If a protection fuse is used in the installation, the certified maximum over-current protection rating is 16A for modules with 6" cells.

The modules are qualified for the application class A: Hazardous voltage (IEC 61730: higher than 50VDC; EN 61730: higher than 120V), hazardous power applications (higher than 240W) where general contact access is anticipated.

8. Possible Failures

Cases of failures are extremely infrequent due to the thorough quality controls to which photovoltaic modules are subject before selling to the public. However, the following cases may be detected, always for reasons alien to the manufacturing process:

Broken glass

Glass is usually broken by external actions, bad installation, stone throwing, etc. Cases of glass broken in transport to the site have also been reported.

Since the glass is tempered, breaks always occur in the form of a total splintering of the surface and the place of impact can be clearly seen. Splintering reduces performance by approximately 30%, but the module can still continue in use, although it is advisable to change it as soon as possible to ensure the installation remains in operation.

Penetration of humidity inside the module

Although this is an unusual failure, it may happen through external scratches in the rear TEDLAR from external aggression. When humidity penetrates into the cell circuit and its connections, corrosion appears which reduces or even breaks the electrical contact of the electrodes with the cell material, preventing electrons being picked up and thus making the module useless. The voltage and intensity drop to zero and the module must be immediately replaced.

It must be pointed out that, as this failure generally ends up being a total one, it is preferable to replace the module when serious degradation is found during an inspection, thus avoiding further costs.

Failures in module connections

Due to the thermal differences between, for example day and night, the module wiring connectors may slacken. This is why connections must be regularly inspected (e.g. every six



months) and tightened if necessary.

The sealing of the junction boxes through cable bushes must be ensured during installation. Should water be detected entering the junction box, its presence on the contacts may cause voltage drops in the circuit and, therefore, a reduction in power generated. Repair work includes cleaning the junctions and changing the junction box or cable bush seal, if any are found to be faulty.

Shadow effect

The shadow or hot spot effect is caused by an isolated shadow on one or several module cells while the rest are receiving high radiation. This situation must be solved by removing the cause of the shadows. Protection diodes described in heading 3 are provided to prevent damage to the cells.

Manufacturing defects

Should there be any, manufacturing defects come up during the first few days of operation and have a very small effect, below one per thousand, due to the thorough quality control performed in AUO's factory. In case of detecting any failure, AUO will provide a new module to replace the damaged one, as established in the product guarantee.

9. Maintenance

Photovoltaic modules need very little maintenance because of their configuration, with no moving parts, and with an interior cell circuit and connection soldering isolated from the outside environment by layers of protective material. At the same time, quality control as performed by AUO is very strict.

Regular cleaning of the module

Dirt piled up on the module's transparent surface reduces its performance and may cause reversal hot spot effects. The problem may become serious in the case of industrial waste and bird droppings. The intensity of the effect depends on the waste's opacity. The layers of dust that reduce the sun's intensity evenly are not dangerous and power reduction is not usually significant. The frequency of cleaning depends, of course, on how quickly dirt accumulates. In many cases, rainfall may reduce or remove the need to clean the modules.

The cleaning operation must be performed, in general, by the user. It simply consists of washing the modules with water and non-abrasive detergent.

Visual inspection of the module

The purpose of visual inspection of the module is to detect possible faults, specifically:

- Possible broken glass.
- Rust on the circuits and soldering of the photovoltaic cells: this is normally due to humidity entering the module through a breakage in the encapsulating layers during installation or transport.



Inspection of connections and cabling

Perform preventive maintenance every 6 months, carrying out the following operations:

- Checking the tightness and condition of the connection cable junctions.
- Checking the junction box sealing. Should sealing faults be observed, the items affected should be replaced and the junctions cleaned. It is important to monitor the junction box sealing, using new seals or a silicon sealing according to the case.

10. CERTIFICATES

- Photovoltaic modules provided by AUO are certified according to the design qualification and type approval standard IEC 61215 edition 2.
- The photovoltaic modules provided by AUO are certified according to the safety qualification standard IEC61730 certified for application class A.
- Modules qualified of safety through EN IEC61730-1 and -2 within this application class are considered to meet the requirements for Safety Class II.