



S Y S T E M

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INSTALLATION AND MAINTENANCE MANUAL OF PV MODULES FAMILY PV MOF1000



— SMART FUTURE —

Intallation and maintenance manual of PV modules - family PV MOF 1000

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1 Introduction

Thank you for choosing ML SYSTEM S.A. as your photovoltaic module supplier. We value your business! This manual contains information regarding electrical and mechanical installation of photovoltaic modules as well as guidelines for maintenance and safety.

! →

Please read this instruction carefully before performing installation, wiring or maintenance on the product in any way. Failure to comply with the instructions provided here might result in a safety hazard and/or invalidation of ML SYSTEM S.A. warranty for the module.

This manual provides information about photovoltaic (PV) modules manufactured by ML SYSTEM S.A. from the PV MOF 1000 family. The modules are designed for standalone (ground) and rooftop photovoltaic installations as well as carports, shelters or photovoltaic tracking systems. The manual applies to the modules based on the mono or polycrystalline silicon. It also covers the modules equipped with additional functionalities such as imprinted ceramic color layer, no-frost functionality, surface or sub-surface laser-engraving or modules equipped with luminescent elements or materials. The manual is especially directed to qualified personnel ("Installer" or "Installers"), including the licensed electricians and installers certified by ML SYSTEM S.A. and/or SEP¹.

The installation manual must be provided to the end user as a part of the documentation of the photovoltaic system and must be kept for the future reference.

Should you have doubts or any further questions regarding this product do not hesitate to contact our Service Dept. at e-mail: serwis@mlsystem.pl or by phone: +48 533 159 156.

1.1 Liability disclaimer

ML SYSTEM S.A. and its' subsidiaries do not assume any responsibility for loss, damage or expense resulting from improper installation, handling, maintenance or use of the product including non-compliance with the instructions provided in this manual. The responsibility is also disclaimed for the loss, damage or expense resulting from or related to the use of third party products.

ML SYSTEM S.A. does not assume and clearly disclaims responsibility for loss, damage or expenses resulting from or related in any way to this installation and maintenance manual. ML SYSTEM S.A. disclaims responsibility for patent infringement or infringement of any third party rights which may result from the use of the product. No license is implied or granted explicitly, or under any patent or patent rights. The information provided in this manual are considered trustworthy but they do not constitute expressed or implied warranty.

The information provided here can be updated without prior notice in accordance to latest safety standards and requirements or due to continuous product improvement. Please visit www.mlsystem.pl/download for the latest version of this manual.

The manual is provided in many languages. In case of discrepancies the overriding version is the polish issue.

Non-compliance with the requirements of this manual may cause an invalidation of the warranty for the photovoltaic modules supplied by ML SYSTEM S.A. at the time of sale.

1.2 IEC requirement information.

The photovoltaic modules supplied by ML SYSTEM S.A. are made of high quality materials and highly efficient solar cells. The quality of the modules manufactured in Poland is confirmed by multiple tests occurring in the production process. The photovoltaic modules are subject to tests and measurements in the R&D department of ML SYSTEM S.A. that exceed the ones included in the current standards, which enables continual improvement and optimization of the products. With proper operation, ML SYSTEM S.A. photovoltaic modules ensure many years of reliable operation.

This product meets all requirements listed by IEC 61215 and IEC 61730 for terrestrial PV modules. The IEC standard covers terrestrial flat-plate PV modules and panels intended for installation on building facades, rooftops and in free-standing photovoltaic installations. This product is not intended for use in highly concentrated sunlight systems. Maximal sun concentration that can be applied to this module is 3 suns. Usage in very low irradiation conditions is permitted. All MOF 1000 modules are designed for application class A (Safety Class II).

The modules can be used for agricultural and marine applications.

For complete information about the product certification please refer to the technical datasheet of your specific module model.

1.3 Warrnaty

Warranty on ML SYSTEM PV modules is presented in a separate document "Warranty Conditions" available at www.mlsystem.pl/download. The instructions provided in this manual is an integral part of the warranty card.

¹ Association of Polish Electrical Engineers

1.4 Module rating

For specific module rating in STC² conditions in terms of I_{SC} (short circuit current), V_{OC} (open circuit voltage), P_{max} (maximal power output) as well as respective temperature coefficients and tolerances please refer to specific data sheet of the desired module type. Your module type is listed on the back label of each individual module.

Each module is supplied with the nameplate placed at the rear of the module. The nameplate contains electrical parameters and safety markings as well as model type. The serial number of the module is laminated under the front glass. For easier identification an example of the nameplate is depicted in the figure 1.

	Manufacturer: ML System S.A. Zaczerne 190G 36-062 Zaczerne Polska	www.mlssystem.pl
Photovoltaic module family: MOF1000 Typ: ML-S6MF/T1-300-992/1639		
Rated power (Pmax):	300	(W)
Power tolerance:	-0 / +5	(%)
Open circuit voltage (Voc):	40.4	(V)
Short circuit current (Isc):	9.69	(A)
Rated voltage (Vmp):	33	(V)
Rated current (Imp):	9.13	(A)
Current and voltage tolerance:	+ / - 3	(%)
Overcurrent protection:	15	(A)
Max. system voltage (Vsys):	1000	(V)
Dimensions:	992x1639	(mm)
 Caution: During exposition to sunlight the installation has maximal voltage of 1000V. Repair and maintenance can only be performed by qualified personnel. Do not disconnect under load.		
		

Figure 1: Example of the nameplate placed at the rear of each photovoltaic module.

2 Safety instructions

2.1 General safety precautions

! → Please read this section carefully before performing any installation, wiring or maintenance on the product.

! → Improper installation, wiring and maintenance may introduce safety hazards and cause an invalidation of warranty. Please refer to chapters 3, 4 and 5 for instructions on installation, wiring and maintenance.

→ Section 3
→ Section 4
→ Section 5

Always comply with the obligatory local regulations with respect to building construction, electrical installations, fire and safety installation. Prior to installation local authorities should be contacted to acquire adequate permits regarding construction and connecting of the photovoltaic installation to the grid. The rooftop photovoltaic system should only be installed on houses, for which the roof construction has been analyzed by a certified construction engineer in order to ensure that the building and roof construction can safely bear the additional load of the photovoltaic installation, including the photovoltaic modules and all necessary mounting elements.

For your own safety do not attempt the rooftop installation before the safety measures are not specified and applied, including but not limited to fall protection, ladders or stairs, and personal protective equipment.

Please apply the following safety guides at all times:

1. Do not attempt to repair or replace any part of the module.
2. Do not disassemble the module.
3. Always check the module for visual defects : broken glass, broken back sheet, broken cables or junction box. Do not install, utilize or clean damaged modules.

! →



Contact with broken or damaged surface of the module on each side poses a danger of an electric shock.

4. Do not attempt to open the junction box.
5. Contact your module supplier if in need of maintenance or repair.

² Standard Test Conditions: Irradiance 1000 W/m², AM 1.5 solar spectrum, temperature 25 deg C

6. Installation should only be performed by the authorized personnel.
7. Use only the equipment, connectors, wiring and supporting construction designed for use in photovoltaic systems.
8. Do not stand on, scratch or otherwise damage either surface of the module (front or rear).
9. Do not allow foreign objects such as cases, tools, covers, shades, construction elements etc. to be put over either surface of the module.



! →

Allowing foreign heavy objects to stand on or scratch the surface of the module might lead to micro-cracks or other damage to the glass. Such damage may be invisible to the naked eye. This might lead to diminished performance or safety hazard. Always treat the module as a glass product and refrain from standing/putting objects on either side of the module.


10. In case of framed modules - do not drill holes in the frame of the module. Additional unprotected damage to the frame might cause an excessive corrosion and compromise the strength of the frame.
11. Do not drill holes in either side of the module plane.
12. Do not scratch the frame of the module.
13. Do not apply paint, glue or any additional cover to any element of the module.
14. Do not use junction box or connecting wires for transportation or holding the module.
15. Do not perform the installation of modules in high wind.
16. Save these instructions for later in an easy reachable place

2.2 Electrical safety

! →

PV modules are sources of voltage when exposed to light. Module interconnect parts pass direct current (DC) when the module is under load. Do not connect or disconnect modules when they are under load. Direct current can arc across gaps and may cause injury and death if improper connection or disconnection is made. Please inspect the module for frayed, torn or damaged leads before use.



The MOF1000 module family is designed and tested for application class A (Safety Class II) of protection against electric shock in accordance to IEC 61140. The modules can be applied in non-restricted access areas.

Following safety guidelines must be followed while connecting the modules:

- Make sure that the inverter has been disconnected from the AC circuit.
- Cover the module surface with an opaque material before making or breaking electrical connections. When connecting/disconnecting PV array cover the surface of all modules in the array.
- Apply the regional and local safety codes and regulations of electrical safety when connecting the modules.
- Electrical connections should only be performed by authorized personnel.
- Remove all metallic items or jewellery prior to installation to reduce hazard of exposure to life electrical circuit.
- Use insulated installation tools and means of personal protection against electrical shock (gloves, safety boots).
- The installation and maintenance should not be carried out on wet modules.

2.3 Packaging, transport, storage.

The modules are carefully packed in cardboard packages and secured against damage in transport. Out of concern for the environment, all parts of the ML SYSTEM S.A. modules packaging are recyclable. The photovoltaic modules should be transported and stored solely in the provided packaging. During handling the of pallets on which the packaging rests the following guidelines should be applied:

1. Protect the pallets from shifting and damage during transport.
2. Do not exceed the max height of the pallet stack. The pallets should be stacked according to the guidelines on the package.
3. The pallets should be stored in a dry and cool place.
4. Use only forklifts with min. 1.25m fork length to handle the pallets.
5. The package should be placed in such way, that the arrows depicted on the package point upwards.
6. Do not lift with a forklift over the long edge of the pallet.

Please follow the guidelines below to properly unpack the photovoltaic modules:

1. Check the packaging and pallet for potential damage which might result from improper transportation and storage. If the packaging and/or pallet is damaged prepare the damage protocol in presence of the courier or forwarding agent representative and inform ML SYSTEM S.A. about the incident. If more than 1/3 of the modules on the pallet have suffered damage you should refuse the delivery and fill in the form "Notification of transport damage", which you can download from www.mlssystem.pl and send to ML SYSTEM S.A.
2. Cut the foil securing the package. Use safe cutting tools. Do not use knives or other cutting tools with the blade directed into the packaging surface.
3. Remove the foil. Cut the fixing tape.
4. Remove the cardboard lid from the top of the package. Check if cardboard spacers at the edges of the modules are in place.
5. Remove modules vertically from the package. This activity is to be performed always by at least two people. Use protective gloves to avoid injuries.
6. When the position of the rest of the modules in the package becomes unstable move them carefully away from the edge of the packaging and place against the cardboard wall of the packaging. Carefully remove the rest of the modules from the packaging.



Step 1: Check the packaging and remove protective elements.



Step 2: Lift the lid.



Step 3: Remove the modules one by one.



Step 4: If the modules become unstable slide them in one place.

The fundamental components of the photovoltaic module which are discussed later in this manual are presented schematically in the figure 2.

Please apply the following safety rules when storing or moving individual modules:

1. Store the modules in dry, ventilated places.
2. Always carry with both hands.
3. Do not put weight on the modules.
4. Do not remove identification and rating labels.
5. Do not expose the modules to an excessive UV radiation during storage.
6. In case of frameless modules - always apply protective pieces to the module corners.
7. Always handle the module by the frame. Do not use glass, junction box or cables for handling.
8. Modules must be unpacked by two people.
9. Do not step, walk and/or jump on the modules.
10. Do not leave modules unsecured or without proper support.
11. Keep electrical contacts clean and dry.

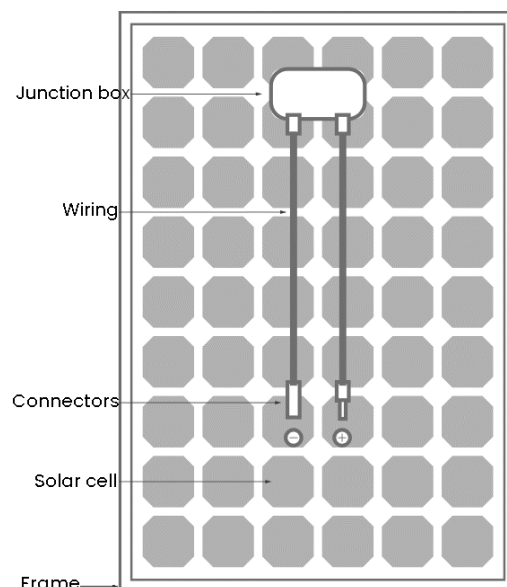


Figure 2: Component of the photovoltaic module.

3 Installation

! →
→ Section 2.1

Please read this section as well as the general safety instruction in section 2.1 carefully before performing installation of photovoltaic modules. You should never install faulty photovoltaic modules.

During planning the installation and exploitation of the photovoltaic systems all applicable standards must be complied with, including:

- EN 1991-1 - EUROCODE 1 - Actions on structures.
- EN 13501 - Fire classification of construction products and building elements.

- EN 60728-11 - Cable networks for television signals, sound signals and interactive services safety - Part 11: Safety.
- EN 62305 - Protection against lightning.
- EN 62446 - Photovoltaic (PV) systems - Requirements for testing, documentation and maintenance.
- EN 60364/VDE 0100 - Low-voltage electrical installations.
- VDE 0105-100 oraz SEP 004 - Exploitation of the electrical installations.
- IEC 62548 - Photovoltaic (PV) arrays - Design requirements.
- IEC 61727 - Photovoltaic (PV) systems - Characteristics of the utility interface.

3.1 Installation site selection

The modules are meant for application in freestanding (ground) and rooftop photovoltaic (PV) installations as well as other facilities which are intended for application of PV modules (shelters, facades, tracking PV systems).

The modules must be mounted in an environment that ensures that the following minimal and maximal operating temperatures are not exceeded:

- minimal operating temperature : -45 °C
- maximal operating temperature : +85 °C

This module is intended for use in general open-air climates. Please do not use the photovoltaic modules in presence of naked flame or highly flammable gases or materials. Do not immerse modules in the water or expose modules continuously to water (ex. in the presence of fountains, sprinkler systems etc.). The modules should not be mounted in places where aggressive chemical substances could cause excessive corrosion or degradation of the materials (ex. strong bases, acids, salt, ammonia etc.). The modules have been tested for corrosion in salt mist and ammonia according to IEC 61701 and IEC 61716. The PV modules should not be mounted on moving vehicles.

Please provide an adequate ventilation of the rear side of the module. Minimal space of 5 cm is recommended.

To avoid the risk of hot-spots and ensure the maximal performance avoid partial shading of the module.

The module should be facing south in northern latitudes and north in southern latitudes. In order to obtain detailed information about selecting directionality and layout of your installation please consult a professional system integrator or installer. ML SYSTEM S.A. recommends minimal installation angle of 10° to ensure the self-cleaning of the module surface under rain fall.

The module is designed for maximal installation altitudes of up to 2000m.

3.2 Installation guidelines

The modules are equipped with mounting points and should be mounted in a supportive substructure. Please make sure that your supportive substructure is made of durable, corrosion resistant material. The minimal distance between the modules should not be smaller than 7mm.

Please obtain information about any necessary approvals for the construction site from local authorities.

- ! →

Never drill additional holes or other mounting features in the module surface or frame.

- ! →

Do not install modules with visibly broken or damaged glass edge or front. The glass damage might propagate with time and cause module failure and safety risk. Always inspect module for damage after installation.
--
- ! →

The module is not intended as a load-bearing element of any kind of structure. Under no circumstances should any artificial load be applied to the module surface or frame including temporary installations (tents, gazebos, umbrellas, hammocks, banners, signboards etc.)
--
- ! →

This product has been certified with fire class C according to IEC 61730/UL 1703. Using materials of lower fire rating in the supportive substructure may result in lower overall fire resistance of the building. Please always adhere to the local laws and regulations regarding building construction when selecting the supportive substructure for the modules. The mounting method does not influence the fire rating of the module.

3.3 Requirements for the supportive substructure

The supporting substructure must be made according to good construction practice and be able to carry the module load. Construction law, including technical construction regulations, must be obeyed when designing the supportive substructure.

Before the installation of the photovoltaic modules examine the technical condition of the supportive substructure. The supportive substructure should guarantee the structural strength to carry the module design load

taking into account maximal permissible deflections. The substructure should be made in accordance with the local building codes and regulations.

Strength and stiffness should be calculated taking into account the self-weight load of the selected module and the maximum allowable load for the module. The supporting substructure should be attached to the ground, buildings or other facilities intended for this (e.g. sheds, facades, PV tracker devices), taking into account the provisions of the construction law.

The supportive substructure may be made of any material complying with the construction regulations and providing adequate construction strength. In case more than one type of metallic material are used please ensure that the components are properly isolated to avoid electrochemical corrosion.

! →

UL 1703 recommends, that the combinations of metallic materials should not exceed the difference of electrochemical potentials by more than 0.5 volts.

→ Section 3.5

The supportive substructure should be adapted to the selected mounting scheme. The selection of the mounting scheme is dependent on the desired module layout in the installation (horizontal or vertical) and the maximal mechanical load that the module can bear. For more information on the module load please refer to section 3.5.

3.4 Mounting configurations

This section describes minimal mechanical requirements for secure mounting of the module to the supportive substructure. Please follow these instructions strictly to guarantee safe usage and to meet the permissible module loads requirements the supportive substructure.

The modules should be mounted with the use of mounting system clamps pressed against the module frame. End or middle clamps should be used depending on the module position in the array. The use of clamps made of aluminium is recommended. The clamps should be fixed to the supportive substructure with stainless steel screws. The system mounting is equipped with M8 screw holes. The screws should be fastened with 8Nm moment. The detail of the end and middle clamp mounting is presented in figures 3 and 4.

! →

The width of the mounting piece (clamp) should be no less than 50mm. The clamp should form a stable, rigid support point for the module.

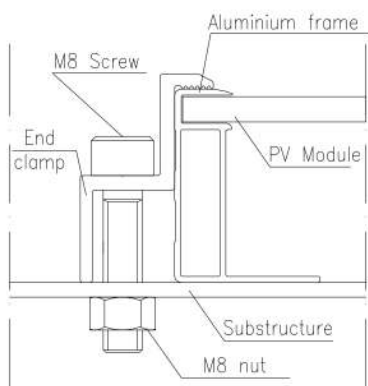


Figure 3: End clamp mounting schematic.

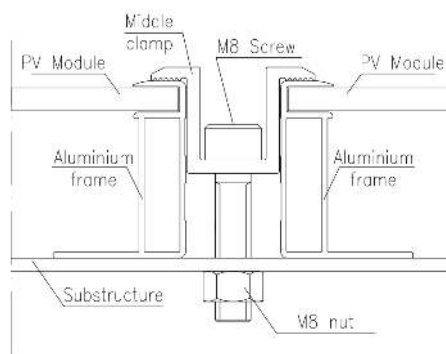


Figure 4: Middle clamp mounting schematic.

We propose 2 installation schemes for mounting the PV module to the supportive substructure - vertical and horizontal. The vertical mounting can be carried out in standard and reinforced version (with additional supports).

3.4.1 Standard vertical mounting

In the standard vertical configuration the module is mounted on two beams with support positions placed on the long side of the module. Please refer to figure 5 for correct placement of the supportive positions.

3.4.2 Reinforced vertical mounting

In the reinforced vertical configuration the module is mounted on four beams with support positions placed on the long side of the module. Please refer to figure 6 for correct placement of the supportive positions.

3.4.3 Horizontal mounting

In the standard horizontal configuration the module is mounted on two beams with support positions placed on the short side of the module. Please refer to figure 7 for correct placement of the supportive positions.

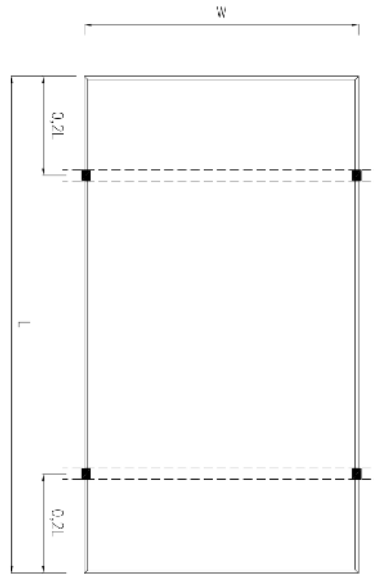


Figure 5: Standard vertical mounting.

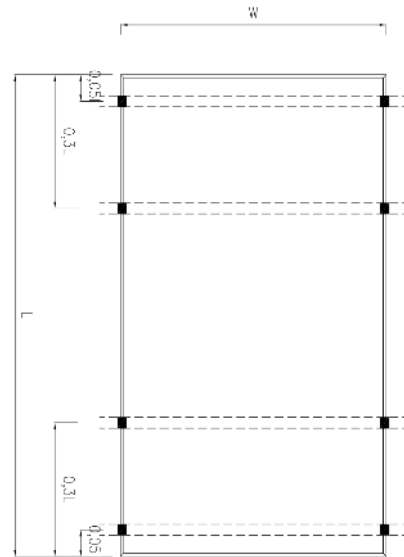


Figure 6: Reinforced vertical mounting.



Figure 7: Horizontal mounting.

3.5 Permissible loads

The permissible module loads depend on the module dimensions and installation scheme. The module dimensions are described on the rating label and technical datasheet provided with your module. Please select the module installation scheme carefully taking into account the possible snow and wind load zones in the installation site.

! →

Please consult system designer and structural engineer to determine snow/wind loads in your geographical area. Never install the module in places where the maximal permissible module load might be exceeded.

The maximal permissible module loads for all possible mounting schemes are given in the table 1.

cell number	Dimensions (L) (W) [mm] [mm]		Max. permissible load (front / rear)		
			Vertical		Horizontal standard [Pa]
			standard [Pa]	reinforced [Pa]	
96	1959	1310	2400 / 2400	5400 / 3600	2400 / 2400
80	1639	1310	2400 / 2400	5400 / 3600	2400 / 2400
72	1959	992	5400 / 3600	8000 / 3600	3000 / 2400
66	1801	992	5400 / 3600	8000 / 3600	3000 / 2400
60	1639	992	5400 / 3600	8000 / 3600	3000 / 2400
54	1480	992	5400 / 3600	8000 / 3600	3000 / 2400
48	1320	992	5400 / 3600	8000 / 3600	3000 / 2400
36	1480	670	8000 / 3600	n.a.	3000 / 2400
24	1004	670	8000 / 3600	n.a.	3000 / 2400
18	1480	350	8000 / 3600	n.a.	3000 / 2400
12	1004	350	8000 / 3600	n.a.	3000 / 2400

Table 1: Permissible module loads in different mounting configurations (front / rear).

To determine the design load of the system the safety factor at least $\gamma= 1.5$ should be applied according to recommendations of IEC 61215. Depending on the construction, location/climate and local construction laws or regulations a higher safety factor might be required.

4 Wiring

4.1 General wiring information

! →
→ Section 2.2

Please read the electrical safety instructions in section 2.2 before performing any wiring of the photovoltaic modules.

The modules have been equipped with the MC4 connector type and can be connected in series or parallel configurations in the module array. When planning and performing wiring please follow the local codes and regulations for DC installations. All wiring should be secured with UV-resistant ties and installed in a manner that minimizes exposure to the direct sunlight. The cables and connectors should be mounted in a way that eliminates the risk of damage resulting from mechanical load. The cables and connectors should not be exposed to moist or water and should not be placed directly on the ground or floor.

All modules are equipped with bypass diodes. Parameters of the bypass diodes are given in the technical documentation of your specific product. In case of partial shading of the module the current generated by non-shaded solar cells is being transferred through the bypass diode limiting the heating up of the module and improving the energy yield.

! →

The bypass diodes are not meant as an overcurrent protection devices!

In case of known or suspected bypass diode failure the installers or the supplier of maintenance services should contact ML SYSTEM S.A. Do not attempt to open the junction box of the module. The replacement of the bypass diodes in the junction box is not permitted and can only be performed by ML SYSTEM S.A.

→ Section 4.6

In case the of parallel connection of the modules the installation should be equipped with a overcurrent protection device (OCPD). More details about parallel connection of the modules are given in section 4.6.

! →

We recommend using the same photovoltaic module type within one photovoltaic system. Using different module types may lead to current or voltage mismatch, which may result in lower system efficiency or reverse current overload. Before connecting modules of different types please consult the photovoltaic system designer.

4.2 Connectors

Please protect non-paired connectors against moist, dust or any other contamination. Only clean and dry connectors meet their protection rating (IP). Please make sure that the plug covers are tightly fastened before connecting the modules. Never perform electrical connection with wet, dirty or faulty connectors. Avoid excessive exposition of the connectors to sun and water. Do not place the connectors directly on the ground or roof surface.

! →

Faulty connections may lead to electric arcing and pose threat of electric shock. Please check if all electrical connection are safely fastened. Make sure that all connectors are fully blocked.

! →

The connections of the module strings should be made using connectors identical to the ones installed originally on the solar cable of the module.

! →

It is allowed to use different connector type in the beginning and end of PV module string in order to connect with an external device (i.e. inverter). In such case the original connectors should be replaced with the connectors identical to the ones used in the external device. The cross-sectional area as well as external diameters of the applied cables must comply with the manual provided by the connector manufacturer. More information on www.mlssystem.pl

Minimal requirements for connectors used in the installation are presented in the table below:

Parameter	Value	Unit
Cable cross section range	≥ 4	[mm ²]
Certification	IEC 62852	
Protection degree	IP65 or higher	
Application class	Class A	
Rated current	≥ 30	[A]
Rated voltage	≥ 1000	[V]
Max. ambient temperature	≥ 85	[°C]
Upper limit temperature	≥ 100	[°C]

Table 2: Minimal requirements for installation connectors.

4.3 Cables and wiring

ML SYSTEM S.A. photovoltaic modules are equipped with two (2), braided, sun-resistant output cables terminated with PV connectors compatible with most installations. The positive (+) terminal has a female connector and the negative (-) terminal has a male connector. The module cabling is designed for series connection (i.e. female (+) to male (-) connections), but can also be used to connect appropriate third-party electrical equipment that may have alternative cabling configurations as long as the connector manufacturer's recommendations are followed.

The minimal requirements regarding the cabling are presented in the table below:

Parameter	Value	Unit
Certification	BS EN 50618	
Cable material	flexible copper	
Cable diameter	≥ 4	[mm ²]
Bending radius	≥ 5xDiameter	[mm]
Insulation safety class	Safety Class II	
Certification	IEC 61730 IEC 62930 EN 50618	
Rated voltage	≥ 1000	[V]
Ambient temperature range	-40 to +90	[°C]
Max. conductor temperature	≥ 120	[°C]

Table 3: Minimal requirements for installation cables

4.4 Grounding requirements

Depending on the system design and the photovoltaic modules used, the system can be equipped with various types of inverters. If a transformer inverter is used, it is recommended to ground the negative (-) or positive (+) pole of the PV array. If a transformerless inverter is used, both poles should remain ungrounded, unless the possibility of earthing has been provided for by the manufacturer. Detailed technical specifications should be checked with the supplier of the inverters and the planner of the PV system.

The grounding of the module depends on the presence of the frame in the module. To determine if a module has a frame, check the module's model code. Code 1 is used for framed modules and code 0 for frameless modules as shown in the following example:

example:

- Framed module: ML-S6MF/T**1**-300-992/1801
- Frameless module : ML-S6MF/T**0**-300-992/1801

Detailed instructions regarding grounding can be found in section 250 NEC. Even if the local codes and regulations and standards do not require protective grounding ML SYSTEM S.A. recommends grounding all frames of the modules to ensure that there is no voltage between current carrying parts and the grounding in all circumstances. A photovoltaic module with exposed current carrying parts is considered compliant with UL 1703 only when it is properly grounded according to the guidelines presented here and requirements of local codes and regulations.

The grounding is performed through connecting of the module frame and all metallic non current carrying parts

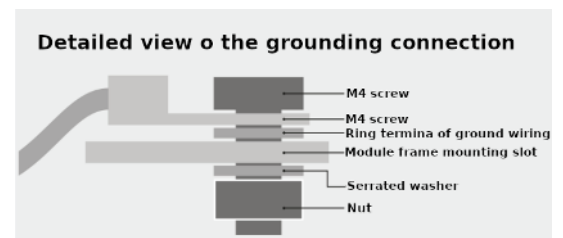


Figure 8: Detailed view of the protective grounding.

of the installations, the photovoltaic modules and the supportive substructure with a continuous grounding cable connected to the earth electrode. The grounding cable may be made of copper, copper alloy or other materials with codes, regulations and standards regarding the elements for grounding installations. Cables should be fixed to the construction in such way as to avoid mechanical damage to the module and/or cable. The cables should be traced in a way which minimizes tensile stress in the cable or connections. Use appropriate fixing elements such as sun resistant cable ties or wire clips which are intended to be installed on the PV module frame. The detailed view of the grounding connection is presented in the figure 8.

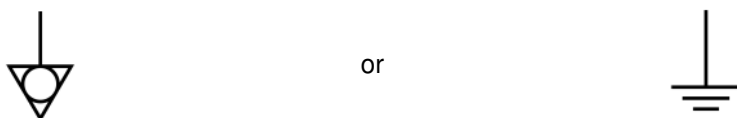
The cables are sun and water resistant. However, whenever possible you should avoid exposing the cables to sun and immersion in water. You should not apply grounding cables of diameter smaller than 4 mm² (12 AWG).

The possibility of electrochemical corrosion between different metallic materials in contact with each other can be minimized if the potential difference between those two materials is low. The grounding method should not cause direct contact of different metals with the aluminium frame of the module, which may cause electrochemical corrosion.

! → UL 1703 recommends, that the combinations of metallic materials should not exceed the difference of electrochemical potentials by more than 0.5 volts.

The module frames and mounting rails are equipped with mounting slots intended for connection of the protective grounding. Those openings should only be used for the grounding purposes and should not be used for general mounting. It is not allowed to drill additional holes in module frame (unless a written permission is given by ML SYSTEM S.A.).

The slot for the wiring terminal or the bonding location of the equipotential bonding conductor is marked with symbols:



The slot for the wiring terminal or the bonding location of the field installed functional earthing conductor is marked with the symbol:



The slot for connection of an external conductor for protection against electric shock in case of a fault or the terminal of a protective ground electrode is marked with the symbol:



If common grounding equipment is used (nuts, screws, star washers, anti-drift washers, flat washers etc.) to connect a replacement grounding device/bonding, the connection must be made according to the instruction provided by the manufacturer of the grounding device.

In case of frameless modules - the module mounting substructure should be properly grounded. Please check with your mounting structure provider for more details concerning the placement of the grounding wiring.

4.4.1 Option A: Protective grounding using ground lugs

The installation of the protective ground lugs must be performed according to the recommendations of the manufacturer. The lug must be fastened to the grounding slot with the use of stainless steel screws or ferrules. Protective washers (split or spring) or counternuts made of stainless steel are required in order to punch through the protective non-conductive coating of the module frame material. The nut supporting the electrical ground connector in place must firmly press down on connector in order to form a reliable electrical connection.

Manufacturer	Part	Material	Required torque
ILSCO	GBL-4DBT	tinned copper	20 do 25 in-lbf (2.3 -2.6 Nm)
Burndy	CL501-TN	tinned copper	20 do 25 in-lbf (2.3 -2.6 Nm)
Tyco Electronics	SolKlip19543 81-4	nickel and tinned copper	15 +4.4/-1.7 in-lbf(1.7+0.5/-0.2 Nm)
ERGOM	KO 0.5/5	tinned copper	20 do 25 in-lbf (2.3 -2.6 Nm)

Table 4: Parameters for the electrical ground connectors (EGC).

4.4.2 Option B: Screw mounting

1. The grounding screw must be fastened in the designated place using only parts made of stainless steel. Insert the stainless steel screw firstly through the stainless steel washer and then through the grounding opening.
2. Loosely hook the stainless steel washers to the grounding screw and tooth lock washer. Bend the ground wiring into omega-like shape (Ω) to ensure tight connection between the screw head and the washer. The ground connector can only contact stainless steel parts.
3. Tighten the screw using 4 Nm (35 in-lbf) torque. The tooth lock washer should be visibly coupled with the frame.
4. Place the ground wiring in a manner that ensures that it does not come into contact with aluminium frame of the module (other than fixed grounding connections).

4.4.3 Option C: Integrated grounding methods

The ML SYSTEM S.A. photovoltaic modules can be grounded by connecting the modules to the already existing grounding system.

! →

The integrated grounding must be certified according to UL 1703 or 2703 for the grounding of photovoltaic systems and used by installed according to the manufacturer's guidelines.

4.5 Serial connection of modules

The modules may be wired in series to produce the desired voltage output. However, please keep in mind, that the output voltage cannot exceed the rated system voltage listed on the label on the rear side of each module. The output voltage should be calculated using formula:

$$V_{OUT} = 1.25 \cdot V_{OC} \cdot N_s \quad (1)$$

Where V_{OUT} is the output voltage, V_{OC} is the open circuit voltage of the module rated on the label on the backside of the module and N_s is the number of modules connected in series.

! →

Never exceed the maximal system voltage!

4.6 Parallel connection of modules

Modules may be connected in parallel to produce the desired current output. The maximal number of modules in parallel depends on the inverter capacity and the current rating of the utilized cables and connectors. Please refer to the applicable reference sheets of your inverter and wiring supplier for more information. If more than 3 parallel modules and/or module strings are connected in parallel then every module and/or module string must be equipped with an overcurrent protection device (OCPD) prior to combining with other strings. Modules are equipped with build-in bypass diodes. Please apply requirements of IEC 60269-6 and local codes and regulations to refine overcurrent protection requirements and limitations in modules connected in parallel. The output current of parallel connected modules can be calculated using the formula:

$$I_{OUT} = 1.25 \cdot I_{SC} \cdot (N_p - 1) \quad (2)$$

! →

Never exceed the maximal system current!

Where I_{OUT} is the output current, I_{SC} is the short circuit current of the module rated on the label on the backside of the module and N_p is the number of modules connected in parallel.

To calculate the required overcurrent protection please apply the following formula:

$$OCPDR = 1.56 \cdot I_{SC} \quad (3)$$

In which OCPDR is the overcurrent protection device rating and I_{SC} is the design short circuit current of module string connected in parallel. If in doubt please consult a professional installation designer or installer. Please find the minimal required parameters for OCPD in the table below.

Parameter	Value	Unit
Type	diode or fuse	
Certification	IEC 60269	
Rated current	≤OPCDR in eq. 3	[A]
Rated voltage	≥1000	[V]
Max. ambient temperature	≥85	[°C]
Upper limit temperature	≥100	[°C]

Table 5: Minimal requirements for installation OCPD.

5 Maintenance

! → Please read the safety instructions in section 2 before performing any maintenance of the photovoltaic modules. Never perform any maintenance on modules which pose a safety hazard!
→ Chapter 2

! → It is recommended to perform maintenance procedures when electrical connections are broken. For safety during connecting/disconnecting PV modules and arrays please refer to section 2.2
→ Section 2.2
→ Section 2.2

This section describes the procedures required for correct exploitation of the photovoltaic modules. Please acquaint yourself with the following information and perform the necessary maintenance within the given time intervals.

The owner is obliged to submit written information about the performed maintenance procedures as well as the possible comments and remarks concerning the irregularities in operation of the module. The information should be submitted within 14 days after each 6 month period of the panel field operation to ML SYSTEM S.A.

! → Violation of the maintenance conditions and procedures mentioned here will result in loss of warranty. The instructions contained here constitute an integral part of the warranty card.

! → Only the personnel which have a written authorization from the supplier (ML System S.A.) or trained by the supplier are entitled to performing the maintenance and/or repair procedures.

5.1 Periodic maintenance procedures

Periodic maintenance of the photovoltaic modules should be carried out according to the following guidelines:

→ Section 2
→ Section 5.2

1. At least once a month the user should perform a visual inspection of the module. Any shading (fallen leaves, sheets of paper, natural dirt, mud etc.) should be removed to ensure maximal performance and avoid the risk of hot-spots in the module. After clearing the surface of the module please perform visual inspection for safety hazards listed in chapter 2
2. At least once every 6 months the user should clean the photovoltaic modules. For details on cleaning of the surface of photovoltaic modules please refer to section 5.2
3. At least once every 6 months the user should check electrical and mechanical connections to ensure that they are safe and intact. Particular attention should be paid to mechanical and electrical safety hazards listed in sections 2.2 and 2.1.
4. During maintenance of the photovoltaic panels please adhere to the local safety regulations and codes in the scope of installation of electrical appliances as well as the regulations concerning the DC installations.

5.2 Cleaning of PV modules

For maximizing the performance of the photovoltaic modules and improving the energy yield we recommend the periodic cleaning of the surface of the modules. Regardless of the general cleanliness of the surface any partial shading should be periodically removed from the surface of the module to avoid the hot-spots.

! → ML SYSTEM S.A. does not recommend using corrosive detergents which are not compliant with glass/coated glass. The use of non-compliant detergents might cause glass surface damage or degradation and lead to lower performance of the photovoltaic modules. Such damage is not covered by the guarantee. Please apply gentle chemical detergents such as ML ECO CLEAN.

Apply the following guidelines while cleaning the photovoltaic modules:

1. Apply soft cloth for cleaning the module surface. Do not utilize high pressure washers.
2. If the module surface cannot be cleaned with clean water use of soft detergents is permissible. Do not use corrosive cleaning agents!
3. Do not use sharp or abrasive objects to clean the surface of the module.
4. Avoid cleaning modules in temperatures above 50°C

5. Do not clean modules which pose a safety risk. Refer to chapter 2 for identification of safety risks.

6 Disposal of the photovoltaic modules

Faulty or worn photovoltaic modules should not be disposed together with the general waste. Proper disposal of the photovoltaic modules has been described in the Directive 2012/19/EU of the European Parliament and of the Council of 4 July 2012 on waste electrical and electronic equipment (WEEE). The photovoltaic modules should be disposed in a separate waste collection point. The Directive WEEE contains general recommendations and each member state can formulate additional local regulations regarding distribution, return and disposal of the photovoltaic modules. In order to return the photovoltaic modules please contact ML SYSTEM S.A. by mail at serwis@mlsystem.pl stating the module type and quantity.



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