

SPRUCE LINE™ photovoltaic modules

Safety, Installation and Operation Manual



ELECTRICAL EQUIPMENT — CHECK WITH YOUR INSTALLER

Evergreen Solar Spruce Line photovoltaic (PV, solar electric) modules are designed to produce DC electrical energy from light. This manual contains important safety, installation and operating information with which you should be familiar before using Evergreen Solar modules.



General Information

- All installation and safety instructions should be understood before attempting to install, wire, operate and maintain the module.
- When installing, observe all local, regional, national and international statutory regulations, guidelines, norms and code requirements.
- Installation or maintenance should only be performed by licensed and qualified professionals.
- Modules produce voltage even when not connected to an electrical circuit or load. Modules produce nearly full voltage when exposed to as little as 5% of full sunlight, and both electrical current and power increase with light intensity.
- Modules can produce higher output than the rated specifications.
- Industry standard rated specifications are made at conditions of 1000W/m² irradiance and 25°C (77°F) solar cell temperature. Colder temperatures can substantially increase voltage and power.
- Ensure that modules are only subjected to ambient temperatures in the range -40 to +80°C (-40 to +176°F).
- Reflection from snow, water or other surfaces can increase light and therefore increase both the current and power generated by the module.
- Do not artificially concentrate light on the module.
- Modules are intended for outdoors, land-based applications only. Modules are not intended for use indoor use or application on moving vehicles of any kind.
- Excluded applications also include, but are not limited to, installations where modules come into contact with salt water or where likely to become partially or wholly submerged in fresh or salt water, examples of which include boats, docks and buoys.
- Use only equipment, connectors, wiring and support frames suitable for use in a solar electric system.
- Follow all safety precautions of other used components.

Handling Safety

- Do not use the junction box to hold or transport the module.
- Do not stand or step on the module.
- Do not drop module or allow objects to fall on module.
- Do not damage or scratch the rear surface of the module.
- Avoid setting the module down hard on any surface, particularly when placing it on a corner.
- Do not disassemble, modify or adapt the module or remove any part or labeling installed by Evergreen Solar. Doing so will void the warranty.
- Do not drill holes in the frame or glass of the module. Doing so will void the warranty.
- Do not apply paint or adhesive to the rear surface of the module.
- Never leave a module unsupported or unsecured.
- Modules are constructed with tempered glass, but must still be handled with care.
- A module with broken glass or torn back-skin cannot be repaired and must not be used since contact with any module surface or the frame can produce electrical shock.

- Broken or damaged modules must be handled carefully and disposed of properly. Broken glass can be sharp and cause injury if not handled with the appropriate protective equipment.
- Work only under dry conditions, and use only dry tools. Do not handle modules when they are wet unless wearing the appropriate protective equipment.

Installation Safety

- Keep children away from the system and modules when installing.
- Do not carry out installation work when there are strong winds.
- When installing modules above ground, avoid any possible falling or other safety hazards by following appropriate safety practices and using required safety equipment.
- Solar electric modules have no on/off switch. Modules can be rendered inoperative only by removing them from light, or by fully covering their front surface with an opaque material, or by working with modules face down on a smooth, flat surface.
- When working with modules in light, follow all applicable regulation regarding working with live electrical equipment.
- Do not touch electrical terminals or the ends of any wire while the module is exposed to light or while installing the module.
- Do not wear metallic jewelry while performing mechanical or electrical installation.
- Never open electrical connections or unplug connectors while the circuit is under load.
- Contact with electrically active parts of the modules, such as terminals, can result in burns, sparks and lethal shock whether the module is connected or disconnected.
- Always use insulated tools and rubber gloves that are approved for working on electrical installations.

Fire Safety

- Refer to your local authority for guidelines and requirements for building or structural fire safety.
- The roof construction and installation may affect the fire safety of a building; improper installation may contribute to hazards in the event of fire.
- For roof application, the modules should be mounted over a fire resistant covering rated for the application.
- It may be necessary to use components such as earth ground fault circuit breakers, fuses and circuit breakers.
- Do not use modules near equipment or locations where flammable gases can be generated or can collect.

Electrical Installation

- Avoid all electrical hazards when installing, wiring, operating and maintaining a module.
- If the total DC system voltage exceeds 100V, the system must be installed, commissioned and maintained by a licensed electrician unless local electrical codes determine otherwise.
- Contact with a DC voltage 30V or more is potentially hazardous.
- Do not use modules of different electrical or physical configurations in the same system.

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- The maximum open circuit voltage of the system must not be greater than the specified maximum system voltage for the module.
- All Evergreen Solar modules are equipped with factory-installed wires and quick connectors. Modules have been designed to be easily interconnected in series.
- Use system wiring with suitable cross-sectional areas and connectors that are approved for use at the maximum short-circuit current of the module.
- Match the polarities of cables and terminals when making the connections; failure to do so may result in damage to the module.
- When reverse currents can exceed the value of the maximum protective fuse marked on the back of the module, a properly rated and certified over-current device (fuse or circuit breaker) must be connected in series with each module or string of modules.
- The rating of the over-current device shall not exceed the value of the maximum protective fuse marked on the back of the module.
- The module contains factory installed bypass diodes located inside the junction box.
- The junction box is not designed or certified to be field accessible or maintainable and should under no circumstances be opened. Opening the junction box may void the warranty.
- Modules with a suspected electrical problem should be returned to Evergreen Solar for inspection and possible repair or replacement as per the warranty conditions provided by Evergreen Solar.
- Warning: connecting modules in reverse polarity to a high current source, such as a battery, will destroy the bypass diodes and render the module inoperative. Bypass diodes are not user replaceable.

Grounding (*Grid-tied applications, U.S. only*)

- Module frames should be connected to an earth ground for safety and protection from lightning.
- The module frame is provided with grounding holes that accommodate self-tapping screws. A #10-32 stainless steel thread cutting screw is recommended.
- Evergreen Solar specifically requires the negative DC pole of the array to be grounded. Since all utility-interactive inverters in the U.S. have ground-fault protection devices that ground the PV array, the addition of an external ground is not required.
- A string of inter-connected modules should not be left in open-circuit conditions for more than two days before the negative pole of the string is connected to an electrical ground. Since some large arrays will take more than two-days to install, the negative end can be temporarily connected to ground if the frames are also grounded while the array is being installed.
- For non grid-tied applications and any applications outside the U.S. or Europe please consult Evergreen Solar for the appropriate grounding guidelines.

Grounding (*Grid-tied applications, Europe only*)

- Evergreen Solar does not require the grounding of module frames, however local or national regulation may require frame grounding. Frame grounding may also be required for lightning (over-voltage) protection purposes.
- All Evergreen Solar modules with a "U" mark on the product identification label do not require electrical grounding.
- All Evergreen Solar modules without a "U" mark on the product identification label require the negative DC pole of the array to be hard grounded. Hard grounding is defined as a direct connection to earth without the use of a resistor.
- The following detailed requirements apply to the electrical grounding of all Evergreen Solar modules without a "U" mark on the product identification label:
 - Any string of inter-connected modules should not be left in open-circuit conditions for more than two days before the negative DC pole of the string is connected to an electrical ground.

- The specific guidelines for hard negative DC pole grounding provided by your inverter supplier should be followed. The guidelines will depend on the specific make and type of inverters which are to be used in your system.
 - For safety reasons, Evergreen Solar recommends that a fuse rated between 0.5 and 1A is installed in the grounding line. Consult your inverter manufacturer for the detailed specification of fuses required for each particular inverter type. The grounding line should be able to carry 125% of the array short circuit current (I_{sc}).
 - In general a grounding cable with a conductor sized 4 to 6 mm² is sufficient for a one or two string array (single inverter). If the system has multiple strings and inverters, all grounding cables should be connected to a common point and then a larger conductor (10 to 16 mm²) be used to connect to the main system ground.
 - The type of hard grounding Evergreen Solar requires is functional and not safety-related. Evergreen Solar requires that cables without green and yellow stripes be used for grounding. Cables with green and yellow stripes indicate safety-related grounding.
 - Safety Class 2 protection is assured as long as all the components or housings used to accomplish grounding are Safety Class 2 certified.
 - Evergreen Solar recommends that the grounding kits or solutions supplied by many inverter manufacturers are used to electrically ground systems with Evergreen Solar modules.
 - Transformer-less inverters cannot be negatively grounded, so Evergreen Solar requires that only inverters are used which can be negatively grounded or which do not expose the module strings to a negative voltage relative to ground.
 - A few types of transformer-less inverters do not expose any part of the module strings to a negative voltage relative to earth. In these cases, and only in these cases, modules without a "U" on the product identification label may be used without grounding the negative DC pole.
 - According to IEC 60364, section 712.312.2 the grounding of active wiring on the DC side of an array is permitted as long as there is electrical separation between the AC and DC sides of the inverter. Inverters with a transformer have galvanic separation between the AC and DC sides, so their operation in electrically grounded PV arrays is completely compatible with IEC standards.
 - Transformer-less inverters do not have galvanic separation between the AC and DC sides and therefore do not meet IEC standards if electrically grounded.
- For non grid-tied applications and any applications outside the U.S. or Europe please consult Evergreen Solar for the appropriate grounding guidelines.

Mechanical Installation

- Modules should be mounted to maximize direct exposure to sunlight and to eliminate or minimize shadowing.
- Even partial shadowing can substantially reduce module and system output.
- Modules must be securely fastened using support frames or mounting kits specialized for PV applications.
- Modules may be mounted at any angle from vertical to horizontal orientation.
- Care must be taken to avoid low tilt angles which may cause dirt to build-up on the glass against the frame edge.
- Dirt build-up on the surface of the module can cause active solar cells to be shaded and electrical performance to be impaired.
- Contact Evergreen Solar for more information regarding minimum recommended tilt angles for specific module products.
- For roof mounted systems, provide adequate rear ventilation under a module for cooling (100mm: 4in gap minimum).
- Clearance of 7mm:¼ in or more between modules is required to allow for thermal expansion of the frames.

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- Always keep the back surface of the module free from any foreign objects or structural elements which could come into contact with the module, especially when the module is under mechanical load.
- Ensure modules are not subjected to wind or snow loads in excess of the maximum permissible loads and are not subjected to excessive forces due to thermal expansion of the support structure.
- Evergreen Solar permits several different mounting methods. The permissible mounting methods and maximum permissible wind and snow loads are detailed in the "Mounting Design Guide" available from Evergreen Solar.
- For permission to use mounting methods not described in the "Mounting Design Guide", please consult Evergreen Solar. Failure to do so will void the warranty and module certification.
- Always follow the mounting equipment vendors' installation instructions in addition to the instructions found in the "Mounting Design Guide". In cases where the vendors' instructions are more stringent than those detailed in the "Mounting Design Guide", the vendors' instructions shall apply.
- In cases where the maximum permissible loading determined by the mounting equipment vendor is less than the maximum permissible load stated in the "Mounting Design Guide", the maximum loads determined by the vendor should always be used.
- The maximum permissible loads apply to uniformly distributed wind or snow loading. Care should be taken to avoid mounting modules in areas that are prone to drifting snow, icicle and/or ice dam formation.

The information in this Manual is based on Evergreen Solar knowledge and experience and is believed to be reliable; but such information including product specifications (without limitations) and suggestions do not constitute a warranty, expressed or implied. Evergreen Solar reserves the right to make changes to the product, specifications or this Manual without prior notice.

Note: This document may be provided in multiple languages. If there is a conflict among versions, the English language version dominates.

Operation and Maintenance

- No routine maintenance is required. However it is advisable to perform periodic inspection of the modules for damage to glass, back-skin, frame, junction box or external electrical connections.
- Check electrical connections for loose connections and corrosion.
- PV modules can operate effectively without ever being washed, although removal of dirt from the front glass can increase output.
- Evergreen Solar modules use front glass with a wear resistant and durable anti-reflection coating designed to improve electrical performance.
- Water can be used for regular washing or rinsing of the coated front glass to remove dust, dirt or other deposits.
- To remove ingrained dirt, the coated glass can be washed with a micro-fiber cloth and ethanol or a conventional glass cleanser.
- No aggressive and abrasive cleansers or chemicals should ever be used on the coated front glass. No alkali based chemicals should be used, including ammonia based solutions.
- Always wear rubber gloves for electrical insulation whilst maintaining, washing or cleaning modules.

Underwriters Laboratories Information (U.S. only)

- 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 Isc and Voc marked on this module should be multiplied by a factor of 1.25 when determining component voltage ratings, conductor capacities, fuse sizes, and size of controls connected to the PV output.
- Refer to section 690-8 of the National Electric Code (NEC) for an additional multiplying factor of 125% (80% de-rating) which may be applicable.
- Conductor recommendations: single conductor cable, type USE-2 (non-conduit), 8-14AWG (2.5-10mm²).

Disclaimer of Liability

Since the use of this Safety, Installation and Operation Manual and the conditions or methods of installation, operation, use and maintenance of the module are beyond Evergreen Solar control, Evergreen Solar does not assume responsibility and expressly disclaims liability for loss, damage, injury or expense arising out of or in any connected with such installation, operation, use or maintenance of the module.

Evergreen Solar assumes no responsibility for any infringement of patents or other rights of third parties that may result from use of the module. No license is granted by implication or otherwise under any patent or patent rights.

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Electrical Specifications at STC*

		ES-160 SL or VL	ES-170 SL or VL	ES-180 SL or VL	ES-190 SL or VL	ES-195 SL or VL	ES-200 SL or VL
P_{mp}	(W)	160	170	180	190	195	200
P_{ptc}^{**}	(W)	141.6	150.6	159.7	168.8	173.3	177.9
V_{mp}	(V)	25.1	25.3	25.9	26.7	27.1	27.5
I_{mp}	(A)	6.38	6.72	6.95	7.12	7.20	7.28
V_{oc}	(V)	32.1	32.4	32.6	32.8	32.9	33.2
I_{sc}	(A)	7.29	7.55	7.78	8.05	8.15	8.25

Number of Cells	108
Bypass Diodes	3 x Type AR2510, 1000V, 25A
Max. Series Fuse/ Max. Reverse Current	15A
UL Rated System Voltage	600V Maximum
TÜV Rated System Voltage	1000V Maximum

Electrical Specifications at NOCT***

		ES-160	ES-170	ES-180	ES-190	ES-195	ES-200
T_{NOCT}	(°C)	45.9	45.9	45.9	45.9	45.9	45.9
P_{mp}	(W)	112.7	120.4	129.0	136.7	140.1	143.2
V_{mp}	(V)	22.2	22.7	23.3	23.8	23.9	24.0
I_{mp}	(A)	5.08	5.30	5.53	5.75	5.86	5.97
V_{oc}	(V)	28.8	29.3	29.8	30.3	30.5	30.7
I_{sc}	(A)	5.68	5.94	6.20	6.46	6.59	6.72

Temperature Coefficients

αP_{mp} (%/°C)	-0.49
αV_{mp} (%/°C)	-0.47
αI_{mp} (%/°C)	-0.02
αV_{oc} (%/°C)	-0.34
αI_{sc} (%/°C)	+0.06

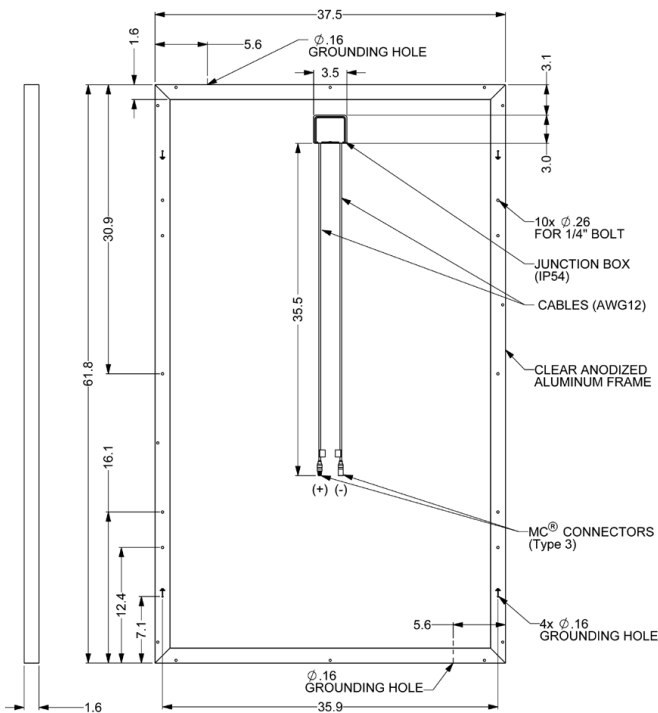
* At Standard Test Conditions: 1000W/m², 25°C cell temperature, AM 1.5 spectrum. Minimum specified power rating is 5% below P_{mp} for ES-160 and ES-170 products, 2% below P_{mp} for ES-180 and ES-190 products and 0% below P_{mp} for ES-195 and ES-200 products; other specifications are +/-10%. Specifications subject to change without notice. Warranty details available on request.

** At PTC (PV-USA Test Conditions): 1000W/m², 20°C ambient temperature, 1 m/s wind speed.

*** At Nominal Operating Cell Temperature Conditions: 800W/m², 20°C ambient temperature, wind velocity 1m/s, AM 1.5 spectrum.

The relative reduction of module efficiency at 200W/m² irradiance in relation to 1000W/m² both at 25°C cell temperature and spectrum AM 1.5 is 0%.

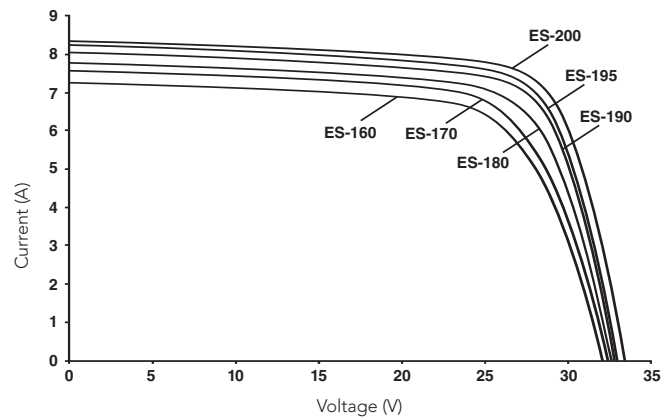
Mechanical Specifications



ES-160, 170, 180, 190, 195, 200

All dimensions in inches; Weight: 40.1 lbs. (18.2 kg)

I-V Characteristics



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