ES-C Series Photovoltaic Panels

Safety, Installation and Operation Manual

This Manual is valid outside North America only (IEC 61730 compliant; Not UL 1703 compliant)

ELECTRICAL EQUIPMENT — CHECK WITH YOUR INSTALLER

Evergreen Solar ES-C Series photovoltaic (PV, solar electric) panels 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 panels.

General Information

- All installation and safety instructions should be understood before attempting to install, wire, operate and maintain the panel.
- When installing, observe all local, regional, national and international statutory regulations, guidelines, norms and code requirements.
- Installation or maintenance should only be performed by qualified professionals.
- Panels produce voltage even when not connected to an electrical circuit or load. Panels produce nearly full voltage when exposed to as little as 5% of full sunlight, and both electrical current and power increase with light intensity.
- Panels can produce higher output than the rated specifications.
- Industry standard rated specifications are made at conditions of 1000W/m^2 irradiance and 25°C (77ºF) solar cell temperature. Colder temperatures can substantially increase voltage and power.
- Ensure that panels 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 panel.
- Do not artificially concentrate light on the panel.
- Panels are intended for outdoors, land-based applications only. Panels are not intended for indoor use.
- Excluded applications also include, but are not limited to, installations where panels 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.
- Each panel is marked with a serial number, including the date of manufacture and the manufacturing location. Example: XXxxYYYYMMDDzzzzzzz
  - XX = country code (49 for Germany, 01 for US, 86 for China)
  - xx = manufacturing building code, can be 01 or higher
  - YYYY = year, MM = month, DD = day
  - zzzzzzz = serial number

Handling Safety

- Do not use the junction box to hold or transport the panel.
- Do not stand or step on the panel.
- Do not drop panel or allow objects to fall on panel.
- Do not damage or scratch the rear surface of the panel.
- Avoid setting the panel down hard on any surface, particularly when placing it on a corner.
- Do not disassemble, modify or adapt the panel 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 panel. Doing so will void the warranty.
- Do not apply paint or adhesive to the rear surface of the panel.
- Never leave a panel unsupported or unsecured.
- Panels are constructed with tempered glass, but must still be handled with care.
- A panel with broken glass or torn back-skin cannot be repaired and must not be used since contact with any panel surface or the frame can produce electrical shock.
- Broken or damaged panels 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 panels when they are wet unless wearing the appropriate protective equipment.
- When storing un-connected panels outside for any length of time, always cover panels which have the glass facing down to stop water collecting inside the panel and causing damage to exposed connectors.

Installation Safety

- Keep children away from the system and panels when installing.
- Do not carry out installation work when there are strong winds.
- When installing panels above ground, avoid any possible falling or other safety hazards by following appropriate safety practices and using required safety equipment.
- Solar electric panels have no on/off switch. Panels can be rendered inoperative only be removing them from light, or by fully covering their front surface with an opaque material, or by working with panels face down on a smooth, flat surface.
- When working with panels 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 panel is exposed to light or while installing the panel.
- 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 panels, such as terminals, can result in burns, sparks and lethal shock whether the panel 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 panels 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 panels near equipment or locations where flammable gases can be generated or can collect.

Electrical Installation –General Recommendations

- Avoid all electrical hazards when installing, wiring, operating and maintaining a panel.
- If the total DC system voltage exceeds 100V, the system must be installed, commissioned and maintained by a qualified professional.
- Contact with a DC voltage 30V or more is potentially hazardous.
- Do not use panels of different electrical or physical configurations in the same system.
- The maximum open circuit voltage of the system must not be greater than the specified maximum system voltage for the panel.
- When reverse currents can exceed the value of the maximum protective fuse marked on the back of the panel, a properly rated and certified over-current device (fuse or circuit breaker) must be connected in series with each panel or string of panels.
- The rating of the over-current device shall not exceed the value of the maximum protective fuse marked on the back of the panel.
- Panels 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.

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Panel Wiring – Cable and Bypass Diodes Installation

- ES-C panels come with a conduit ready junction box designed to be used with standard wiring, watertight strain relief fittings and conduit connections.
- To open the junction box, loosen the two captive screws in the cover. The cover is designed to remain open during wiring and cannot be removed from the panel.
- The junction box has a gasket that ensures the waterproof integrity. Check that the gasket is in the right position before securing the junction box. Do not over-tighten the cover screws.
- The junction box has four (4) 22mm Ø knockouts; two (2) on the bottom and one on each side. Use a tool such as a flat screwdriver to remove the knockouts. Remove only the required knockouts by hitting the perimeter and not the center as shown in Figure 1.
- Before running wires through the knockouts, it is required to install a watertight strain relief or conduit.
- Use the appropriate (M20 x 1.5) or (PG 13.5) watertight cable strain relief depending on your installation and the cable diameter. Table 2 shows some of the (M20 x 1.5) or (PG 13.5) options.
- Knockouts are designed to attach to any standard M20 or PG 13.5 rigid or flexible conduit.
- Steel or nylon lock nuts can be used. Make sure lock nuts are properly tightened to avoid ingress of humidity or water inside the junction box.
- Cables used to wire ES-C panels may be single or two conductors, from 14 AWG (2.5mm^2) up to 10 AWG (6mm^2) gauge.
- For cables exposed outdoors, use only sunlight resistant cables rated for 90ºC and wet locations. Table 1 shows the outdoor sunlight resistant cable options.
- For cables installed in conduit, types THWN-2, RHW-2 and XHHW-2 are recommended.

Wire Type	Insulation (Jacket)	Character-istics	Watertight Strain Relief
USE-2	XLP/XLPE cross-linked polyethylene	Underground service entrance	(M20 x 1.5) or (PG 13.5) with 1 or 2 round holes. Steel or nylon lock nut.
TC (Tray)	Thermoplastic (PVC, Nylon). XLP/XLPE for conductors.	2-conductor, direct burial	(M20 x 1.5) or (PG 13.5) with 1 oval hole. Steel or nylon lock nut.
PV WIRE	XLP/XLPE cross-linked polyethylene Thicker jacket per UL4703	Ungrounded arrays, Transformer-less inverters.	(M20 x 1.5) or (PG 13.5) with 1 round hole. Steel or nylon lock nut.

Table 1. Sunlight 90ºC Wet Resistant Cables.

Manufac-turer	Part Number (Black & Gray)	Opening (Cable range)	Cable Type Fit
Hummel	CD16NS-01 & CD16NS-02	One oval, 6.1mm x 14mm (0.24" x 0.55")	TC (Tray) 2.5mm^2/2 (AWG #14/2), 4mm^2/2 & 6mm^2/2 (12/2 &10/2)
Hummel	CD13NR-BK & CD13NR-GY	One round, 5.1mm to 8.9 mm (0.2" to 0.35") Ø	PV WIRE 2.5, 4, 6mm^2 (AWG #14,12 &10) USE-2 2.5, 4, 6mm^2 (AWG #14,12 & 10)
Hummel	CD13N4-BK & CD13N4-GY	Two round, 5.1mm (0.2") Ø	USE-2 2.5, 4, 6mm^2 (AWG #14,12 & 10)
Heyco	4340 & 4341 3216 & 3217	One round, 4.3mm to 11.4mm (0.17" to 0.45") Ø	PV WIRE 2.5, 4, 6mm^2 (AWG #14,12 &10) USE-2 2.5, 4, 6mm^2 (AWG #14,12 & 10)

Table 2. Watertight Strain Reliefs

- The panel contains factory installed bypass diodes located inside the junction box. These diodes are designed to protect the panel against partial shading conditions and should not be removed.
- Diodes can be easy replaced in the field if necessary. Use only Super Barrier type diodes, Diodes Inc SBR10U45SD1, 45V, 10A or Diotec SB1240. Diodes should be installed as shown in Figure 2.

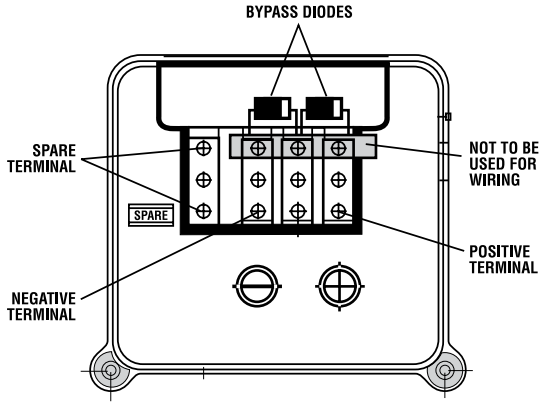


Figure 2. Junction Box Components

- ES-C series panels are factory wired for 12V nominal operation and are not intended to be reconfigured for other voltages.
- The electrical connection block has three (3) double screw terminals; positive (+), negative (-) and spare. It is recommended that the top screws of the terminals be reserved for the bypass diodes, and the output wiring be connected only to the bottom screws. Junction box components are described in Figure 2.
- Match the polarities of cables and terminals when making the connections; failure to do so may result in damage to the panel.
- The Spare terminal can be used to wire arrays at different voltage configurations. Figure 3. Shows examples of the standard 12, 24 and 48V configurations.

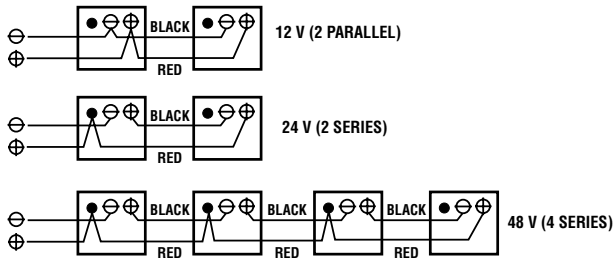
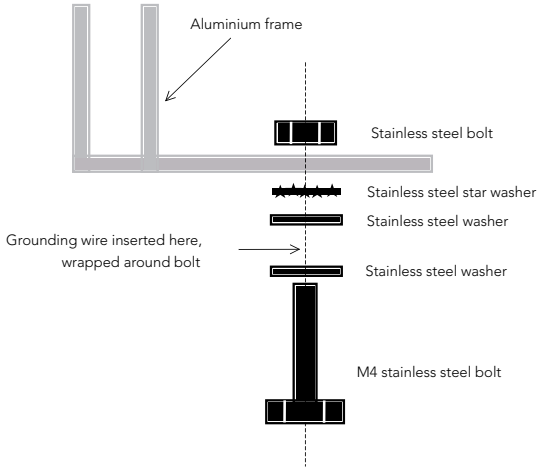


Figure 3. Wiring Examples

Grounding

- Evergreen Solar does not require the grounding of panel frames, however local or national regulations may require frame grounding. Frame grounding may also be required for lightening (over voltage) protection purposes.
- The panels can be grounded using the 4mm diameter holes provided in the frame. The grounding wire can be attached to the panels using a stainless steel bolt (size M4) with stainless steel washers, as shown in the following diagram. The grounding wire size and earthing method must be in accordance with local requirements.



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Mechanical Installation

- Panels should be mounted to maximize direct exposure to sunlight and to eliminate or minimize shadowing.
- Even partial shadowing can substantially reduce panel and system output.
- Panels must be securely fastened using support frames or mounting kits specialized for PV applications.
- Panels 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 panel 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 panel products.
- For roof mounted systems, provide adequate rear ventilation under a panel for cooling (100mm: 4 in. gap minimum).
- Clearance of 7mm:¼ in or more between panels is required to allow for thermal expansion of the frames.
- Always keep the back surface of the panel free from any foreign objects or structural elements which could come into contact with the panel, especially when the panel is under mechanical load.
- Ensure panels 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 Guide available from Evergreen Solar (IEC 61730 compliant version).
- For permission to use mounting methods not described in the Mounting Guide (IEC 61730 compliant version), please consult Evergreen Solar. Failure to do so will void the warranty and panel certification.
- Always follow the mounting equipment vendors' installation instructions in addition to the instructions found in the Mounting Guide (IEC 61730 compliant version). In cases where the vendors' instructions are more stringent than those detailed in the Mounting Guide (IEC 61730 compliant version), 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 Guide (IEC 61730 compliant version), 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 panels in areas that are prone to drifting snow, icicle and/or ice dam formation.

Operation and Maintenance

- No routine maintenance is required. However it is advisable to perform periodic inspection of the panels for damage to glass, back-skin, frame, junction box or external electrical connections.
- Check electrical connections for loose connections and corrosion.
- PV panels can operate effectively without ever being washed, although removal of dirt from the front glass can increase output.
- Water can be used for regular washing or rinsing of the front glass to remove dust, dirt or other deposits.
- To remove ingrained dirt, the 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 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 panels.

IEC 61730 Required Information

- The Evergreen ES-C series panels have been qualified for Application Class A.
- Panels rated for use in Application Class A may be used in systems operating at greater than 50V DC or 240 W, where general contact access is anticipated.
- Panels qualified to IEC 61730 within Application Class A are also considered to meet the requirements for safety class II.
- Under normal conditions, a photovoltaic panel 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 panel 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.
- Conductor recommendations: single conductor cable, type USE-2 (non-conduit), or PV WIRE 14 AWG minimum (2.5mm^2 minimum).
- Maximum number of series/parallel panel configurations: a maximum of 2 strings in parallel may be used without an over-current protection device in series with each string. 3 or more strings in parallel may be used if a properly rated and certified over-current protection device is installed in series with each string.
- To ensure that the string voltage does not exceed 1000V, a maximum of 35 panels may be connected in series at an ambient temperature of -40°C.

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Electrical Specifications at STC*

	ES-C-70 -fa5	ES-C-80 -fa5	ES-C-110 -fa2	ES-C-120 -fa2	ES-C-115 -fa4	ES-C-125 -fa4
P_{mp} (W)	70	80	110	120	115	125
V_{mp} (V)	17.50	18.23	17.27	17.27	17.92	18.36
I_{mp} (A)	4.00	4.39	6.57	6.95	6.42	6.81
V_{oc} (V)	21.70	22.51	20.92	21.34	22.30	22.63
I_{sc} (A)	4.56	4.78	7.33	7.62	7.15	7.37

Electrical Specifications at NOCT**

	ES-C-70 -fa5	ES-C-80 -fa5	ES-C-110 -fa2	ES-C-120 -fa2	ES-C-115 -fa4	ES-C-125 -fa4
P_{mp} (W)	51.2	58.6	80.5	87.8	84.2	91.5
V_{mp} (V)	16.01	16.68	15.33	15.80	16.40	16.80
I_{mp} (A)	3.20	3.51	5.26	5.56	5.14	5.45
V_{oc} (V)	19.86	20.60	19.14	19.53	20.40	20.71
I_{sc} (A)	3.65	3.82	5.86	6.10	5.72	5.90
T_{NOCT} (°C)	45.4	45.4	45.4	45.4	45.4	45.4

*At Standard Test Conditions: 1000W/m^2, 25°C cell temperature, AM 1.5 spectrum. Minimum specified power rating is 5% below Pmp for all products; other specifications are +/-10% of measured values per ASTM E 892. Specifications subject to change without notice. Warranty details available on request.

** At Nominal Operating Cell Temperature Conditions: 800W/m^2, 20°C ambient temperature, wind velocity 1m/s, AM 1.5 spectrum.

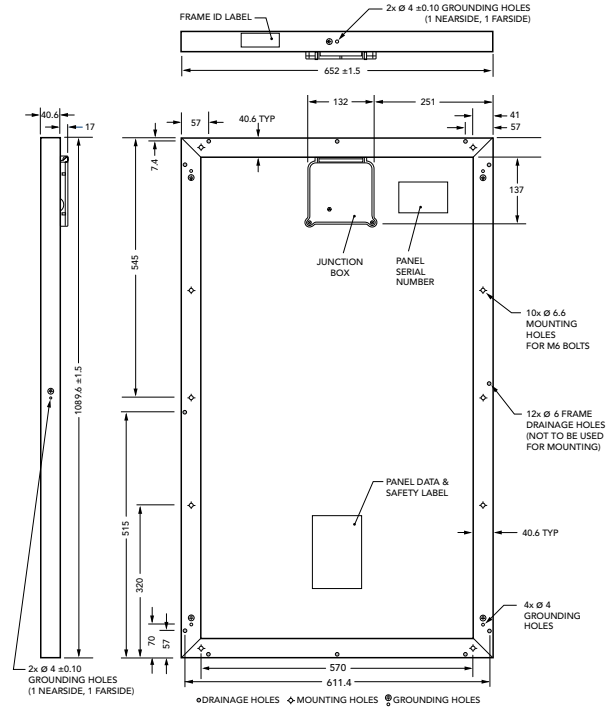
The relative reduction of panel efficiency at 200W/m^2 irradiance in relation to 1000W/m2 both at 25°C cell temperature and spectrum AM 1.5 is 0%.

	ES-C-70, 80 -fa5	ES-C-110, 120 -fa2	ES-C-115, 125 -fa4
Individual Cell Size	150 x 50 mm	150 x 80 mm	150 x 77 mm
Number of Cells	76	72	76
Bypass Diodes	Use Only Super Barrier type diodes, Diodes Inc SBR10U45SD1, 45V, 10A or Diotec SB1240, 40V, 12A.		
Max. Series Fuse/ Max. Reverse Current	8A	15A	15A
TÜV Rated System Voltage	1000V DC Maximum		

Temperature Coefficients

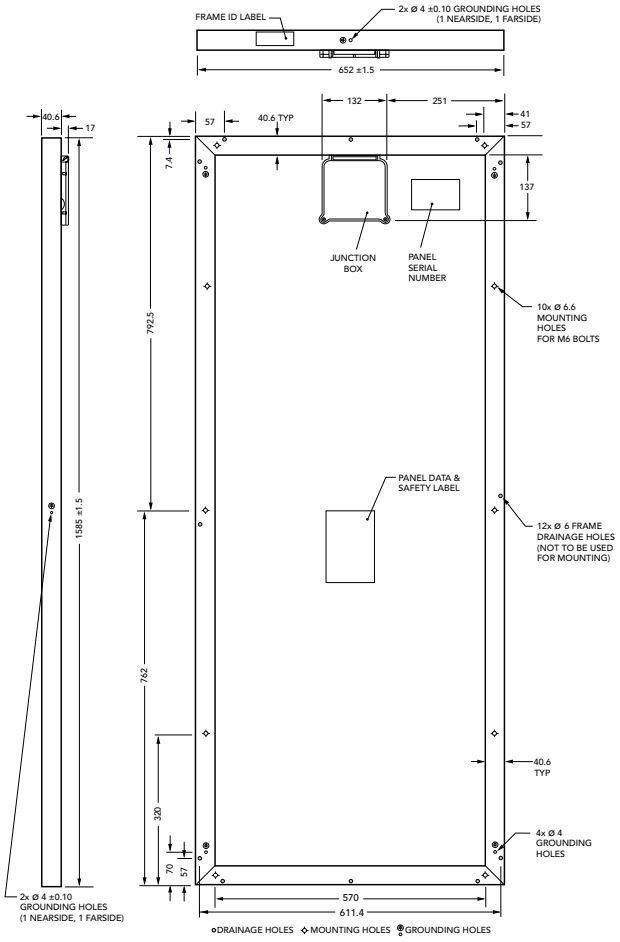
γP_{mp}	-0.43	(%/°C)
βV_{mp}	-0.40	(%/°C)
αI_{mp}	-0.03	(%/°C)
βV_{oc}	-0.31	(%/°C)
αI_{sc}	+0.05	(%/°C)

Mechanical Specifications



ES-C-70, 80 - fa5

All dimensions in millimeters; Weight: 8.6 kg (19 lbs.)



ES-C- 110, 120 – fa2, 115, 125 – fa4

All dimensions in millimeters; Weight: 12.3 kg (27 lbs.)

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Think Beyond.

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