

# FS Series 2 PV Module User Guide – North America

## 1.0 Introduction

First Solar Series 2 PV Modules are manufactured in state-of-the-art facilities using a breakthrough process that rapidly deposits thin films of compound semiconductor material on glass. The modules have been designed to have a long operating life and high energy yield—if installed, operated, and serviced in accordance with the instructions in this User Guide as well as in the System Design and Application Document (PD-2-303).

### 1.1 Before You Begin

This document provides guidelines and information on First Solar FS Series 2 PV Modules for system designers, installers, and maintenance personnel. Read this User Guide thoroughly before beginning any work related to the installation, operation, or maintenance of the First Solar Series 2 PV Module. Only qualified personnel should install, operate, or maintain a PV module or system.

Failure to follow installation and handling instructions may result in injury.

Failure to maintain proper operating condition requirements for the modules will void the warranty (refer to First Solar FS Series Module Warranty Terms & Conditions PD-5-102).

This guide pertains to modules installed within North America only. If a module is being installed outside of North America, contact First Solar or the product distributor for the User Guide appropriate for other geographic areas.

Keep this User Guide for future reference.

Guidelines related to workmanship are beyond the scope of this document and are not covered in this document.

## 1.2 Key Product Features

- ❖ High energy production in real-world conditions.
- ❖ Size and weight that enables efficient handling and installation.
- ❖ Easy, quick-connect wiring for fast interconnection.
- ❖ Internationally recognized product certifications.
- ❖ Five-year limited material/workmanship and twenty-five year limited power output warranties as outlined in “First Solar FS Series Module Warranty Terms & Conditions” (PD-5-102).



The FS Series 2 PV modules may produce voltage in excess of 90 Volts DC ( $V_{DC}$ ) and current in excess of 1.0 Amp when exposed to sunlight. **A single module could create a lethal shock hazard during hours of daylight, including periods of low light levels.** The danger increases as modules are connected together in series and/or parallel. To avoid fire and/or injury due to ground fault and associated electrical hazards:

- Do not unplug PV module connections while under load. Do not disconnect the module connectors during daylight hours unless the module is in an open circuit condition or all modules in series and parallel are covered with an opaque material, such as a tarp or blanket.
- Repair or replace damaged wires immediately. Keep all array wiring out of reach of non-qualified personnel.



- Do not concentrate light on the module in an attempt to increase power output.
- Never allow the PV array open-circuit voltage to exceed 1000V<sub>DC</sub> under any condition
- Replace broken modules immediately.
- Repair any ground faults immediately.
- Do not work on modules or systems when the modules or wiring are wet.

Reverse currents higher than the rated values for a First Solar module (reverse current overload), may result in module failure, including module breakage. Extreme and continuous reverse current overload conditions may cause a fire or create electrical shock hazards. To avoid reverse current overload:

- Maintain equivalent voltage in parallel strings by installing an equal number of modules per string within the same source circuit. Failure to install modules with balanced voltage in parallel strings can result in voltage imbalance.
- Comply with all previously noted practices to prevent and repair ground faults.

It is the responsibility of the PV system installer to ensure compliance with all local building codes. As a minimum level of protection, all building mounted PV systems should utilize Ground Fault Circuit Interrupters and Arc Fault Circuit Interrupters to minimize risk of electrical shocks and fires.

Wear safety glasses (ANSI Z87.1-2003) and cut-resistant gloves when working with modules.

## 2.0 Regulatory Compliance

It is the responsibility of the installer and/or system integrator to ensure compliance

with all local electrical codes which may be applicable.

- Before beginning the PV system design and installation, contact appropriate local authorities to determine local code, permit, and inspection requirements.
- In the United States, refer to Article 690 and/or Article 691 of the National Electrical Code (NEC) which applies to “Photovoltaic Systems.”
- For systems installed in Canada, installation shall be in accordance with CSA C22.1, Safety Standard for Electrical Installations, Canadian Electrical Code, Part 1.

First Solar FS Series 2 PV Modules are Listed by a Nationally Recognized Test Laboratory to UL 1703, the standard for Flat-Plate Photovoltaic Modules and Panels.

To maintain the modules’ application as a UL Listed product:

- Use only components that have been Recognized or Listed by Underwriters Laboratories (UL) for their intended purpose.
- Ensure the PV array open-circuit voltage does not exceed 600V<sub>DC</sub>.
- Install modules with mounting systems that have been evaluated for UL Listed application as specified in First Solar Application Note PD-5-320 NA.
- Protect modules from reverse currents in excess of the Maximum Series Fuse rating of 2A.

FS Series 2 PV modules meet the requirements of Safety Class II and are tested and certified per IEC 61730 Application Class A for a maximum system

voltage of 1000V with maximum overcurrent protection rating of 2A.

FS Series 2 PV modules are tested and certified per IEC 61646 for a maximum system voltage of 1000V.

### 3.0 Electrical Specifications

| Model Numbers and Ratings at STC <sup>1*</sup> |                      |                    |                    |                    |                    |                    |
|--|----------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
| Nominal Values                                 |                      | FS-270<br>FS-270-2 | FS-272<br>FS-272-2 | FS-275<br>FS-275-2 | FS-277<br>FS-277-2 | FS-280<br>FS-280-2 |
| Nominal Power (+/-5%)                          | P <sub>mpp</sub> (W) | 70                 | 72.5               | 75                 | 77.5               | 80                 |
| Voltage at P max                               | V <sub>mpp</sub> (V) | 65.5               | 66.6               | 68.2               | 69.9               | 71.2               |
| Current at P max                               | I <sub>mpp</sub> (A) | 1.07               | 1.09               | 1.10               | 1.11               | 1.12               |
| Open Circuit Voltage                           | V <sub>oc</sub> (V)  | 88.0               | 88.7               | 89.6               | 90.5               | 91.5               |
| Short Circuit Current                          | I <sub>sc</sub> (A)  | 1.23               | 1.23               | 1.23               | 1.22               | 1.22               |
| Maximum System Voltage                         | V <sub>sys</sub> (V) | 1000 (600 UL)      |                    |                    |                    |                    |
| Maximum Series Fuse                            | I <sub>cr</sub> (A)  | 2                  |                    |                    |                    |                    |

\* All ratings at Standard Test Condition (1000W/m<sup>2</sup>, AM 1.5, 25°C Cell Temperature) +/-10%

| Model Numbers and Ratings at STC <sup>1*</sup> |                      |               |          |          |          |          |
|--|----------------------|---------------|----------|----------|----------|----------|
| Nominal Values                                 |                      | FS-270-W      | FS-272-W | FS-275-W | FS-277-W | FS-280-W |
| Nominal Power (+/-5%)                          | P <sub>mpp</sub> (W) | 70            | 72.5     | 75       | 77.5     | 80       |
| Voltage at P max                               | V <sub>mpp</sub> (V) | 67.3          | 67.3     | 67.3     | 67.3     | 67.3     |
| Current at P max                               | I <sub>mpp</sub> (A) | 1.09          | 1.09     | 1.20     | 1.20     | 1.20     |
| Open Circuit Voltage                           | V <sub>oc</sub> (V)  | 92.2          | 92.2     | 92.2     | 92.2     | 92.2     |
| Short Circuit Current                          | I <sub>sc</sub> (A)  | 1.24          | 1.24     | 1.36     | 1.36     | 1.36     |
| Maximum System Voltage                         | V <sub>sys</sub> (V) | 1000 (600 UL) |          |          |          |          |
| Maximum Series Fuse                            | I <sub>cr</sub> (A)  | 2             |          |          |          |          |

\* All ratings at Standard Test Condition (1000W/m<sup>2</sup>, AM 1.5, 25°C Cell Temperature) +/-10%

Electrical specifications are subject to change. See the FS Series 2 datasheet (PD-5-401-02 NA) and module label for additional electrical ratings.

### 3.1 System Derating Factors

Under normal conditions, a photovoltaic module may experience conditions that produce more current and/or more voltage than reported at Standard Test Conditions. Accordingly, when determining component ratings, the values listed for open circuit voltage should be multiplied by a calculated factor based on the low temperature open circuit voltage temperature coefficient. Refer to First Solar Application Note PD-5-435 for additional information on the calculation of this voltage multiplication

factor. Values listed for current should be multiplied by 1.25. Refer to Section 690-8 of the National Electrical Code for an additional multiplying factor of 125 percent (80 percent derating) which may be applicable in computation of maximum circuit current for proper conductor sizing.

### 4.0 Installation: Mounting



Physically damaged modules may cause ground faults and associated electrical hazards. To avoid these conditions:

- Handle modules with care during installation, as heavy impact on the front, back, or edges could result in damage to the module.
- Do not stack or carry multiple modules on top of one another after removal from factory packaging to minimize the risk of breakage.
- Do not lift or pull on modules using lead wires or strain relief wire loops to minimize the risk of wire damage.



Do not install the modules in high wind or wet conditions to reduce the likelihood of injury.



Wear safety glasses (ANSI Z87.1-2003) and cut-resistant gloves when working on non-interconnected modules or systems.



Wear electrically rated PPE when working on interconnected modules or system components.

Mounting of the FS Series 2 PV module to a suitable structure can be done by attaching the module directly to the structure using retaining clips (see Figure 5.1).

Modules used in UL Listed applications

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must be installed with approved mounting systems as specified in First Solar Application Note PD-5-320 NA.

Additional mounting systems may be approved for use. Candidate retaining clip designs must meet the technical requirements specified in First Solar Application Note PD-5-320, and must be approved for use by First Solar prior to installation. The mounting system design must provide adequate support for the glass laminate module to prevent damage from occurring when the module is subjected to wind loads of 130km/h, with a safety factor of 3 for gusty conditions. The location of the clips shall be along the 1200mm length of the module and the center point of the clip shall be located between 250mm and 300mm from the module edge. See Figure 5.1 for allowed location. Retaining clips must each provide a recommended minimum 80mm module surface contact length, with a front side module surface contact width between 13mm and 15mm, and a minimum back side module surface contact width of 15mm. Rubber gasket material, or equivalent, must be used between the module and both the clip and mounting structure to provide adequate protection of the glass laminate module. No direct contact of rigid structures is permitted against the surface or edges of the glass laminate.

All mounting structures must provide a flat plane for the modules to be mounted on, and must not cause any twist or stress to be placed on the module.

Modules should not be installed in a way that restricts air circulation to the backside of the module. Modules generate heat and require adequate airflow for cooling.

Installation locations and module support structures should be selected to ensure modules are never submersed in standing

water or covered by snow drifts.

Heavy construction and trenching should be completed prior to module installation to minimize debris and dust.

Ensure any soil binding agents or salts used for on-site dust control do not spray, splash, or drift onto the surface of the modules.

The UL approved design load of FS Series 2 PV modules is 30 lb/ft<sup>2</sup>. Maximum allowable force on modules may not exceed 2400 Pa without additional module support that must be tested and approved by First Solar.

For rooftop mounting, modules must be mounted over a fire resistant roof covering rated for the application. The recommended minimum standoff height is 3.25 in. Modules used in UL Listed rooftop applications must be installed with approved mounting systems as specified in First Solar Application Note PD-5-320 NA. If alternate mounting means are employed, this may affect the Listing fire class ratings.

#### 4.1 Location, Angle, and Tilt

To maximize performance, modules should be located in an area that receives direct sunlight from mid morning to mid afternoon (typically 9:00 a.m. to 3:00 p.m.). Avoid locating the modules where shadows may be caused by buildings, trees, etc.

PV performance modeling software should be used to determine the optimum orientation and tilt angle for each location.

#### 4.2 Electrical Interconnection

First Solar FS Series 2 PV Modules are pre-configured with industry standard connectors that are “touch proof” with all live parts protected against accidental contact and protected against polarity reversal. The connectors are UV and weather resistant from -40°C to +90°C, and rated for 1000V<sub>DC</sub> (600V<sub>DC</sub> UL) and 20A

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minimum (before derating for ambient temperature).



Damaged wires, connectors, or junction boxes may cause ground faults, and associated electrical hazards, including electrical shock. To avoid these conditions:

- Protect unmated connectors from dust and moisture by using sealing caps (not provided, available from connector manufacturer).
- Limit module connectors to 10 or fewer plug cycles.
- Do not pull lead wires tight at any time. After installation, the connected wire must not be under stress or tension.
- Do not use junction box assembly and lead wire strain relief loops to secure excess wire or to bear weight greater than that of a (properly wire managed) module's own wire and mated connector pair.
- Connector bodies and cables should not be tightly secured at both ends to any mounting structure to allow for thermal expansion and contraction.
- Secure wire or connected components so that no loose wires or components are hanging within 1.5 feet (0.46m) of the ground in free field applications, and so that wire/components are hanging clear of roof coverings or pooled water in rooftop applications.
- Ensure connectors are fully mated.
- Ensure wire securement methods,

such as use of cable ties, do not damage wire insulation. The recommended minimum wire bend radius is 2.25 inches.

- Ensure wires are not in contact with sharp edges of the mounting structure to avoid abrading the wire sheath.
- Inspect and maintain wire management requirements over the life of the plant.



Modules with different FS Series numbers have significantly different electrical operating characteristics and should not be interconnected within the same string to prevent power output loss and voltage imbalance conditions that may create the risk of reverse current overload.

Components used to interconnect the modules must be compatible with the connectors, and provide proper system operation and fault protection as required by any applicable codes. Field wiring must be a minimum of #12AWG, rated for 90°C, and be of a type approved for use in accordance with the NEC.

When connecting First Solar FS Series 2 PV Modules in a series string, ensure that the system design voltage limit is not exceeded. For 1000VDC applications, this is typically ensured by limiting series strings to 10 modules or less. For 600VDC applications, this is typically ensured by limiting series strings to 6 modules or less.

FS Series 2 PV modules are designed for interconnection solely with grid-connected PV inverters capable of continuous operation at the maximum power point of the PV array. All inverters must meet the technical requirements specified in First Solar Application Note PD-5-310 and must

| Specifications | FS Series 2 PV Module |                      |
|----------------|-----------------------|----------------------|
| Length         | 1200mm                | 47.25 in             |
| Width          | 600mm                 | 23.63 in             |
| Thickness      | 6.8mm                 | 0.27 in              |
| Area           | 0.72m <sup>2</sup>    | 7.75 ft <sup>2</sup> |
| Weight         | 12kg                  | 26.5 lbs             |
| Fire Rating    | Class C               | Class C              |

be approved by First Solar prior to installation. When connecting modules or module strings in series and/or parallel, ensure inverter ratings are appropriate.

First Solar recommends that modules not be operated in open or short circuit conditions for more than ninety (90) consecutive days to avoid a potential reduction in energy output over the life of the modules.

#### 4.2.1 Grounding Method

First Solar FS Series 2 PV Modules have no exposed conductive surfaces and do not require equipment grounding. In the U.S., the mounting structure must be grounded per the requirements of the NEC, sections 250 and 690.

#### 4.2.2 Overcurrent Protection

FS Series 2 modules have a maximum series fuse rating of 2A as defined by UL 1703 test methods.

FS Series 2 modules have a maximum overcurrent protection rating of 2A as defined by IEC 61730 test methods.

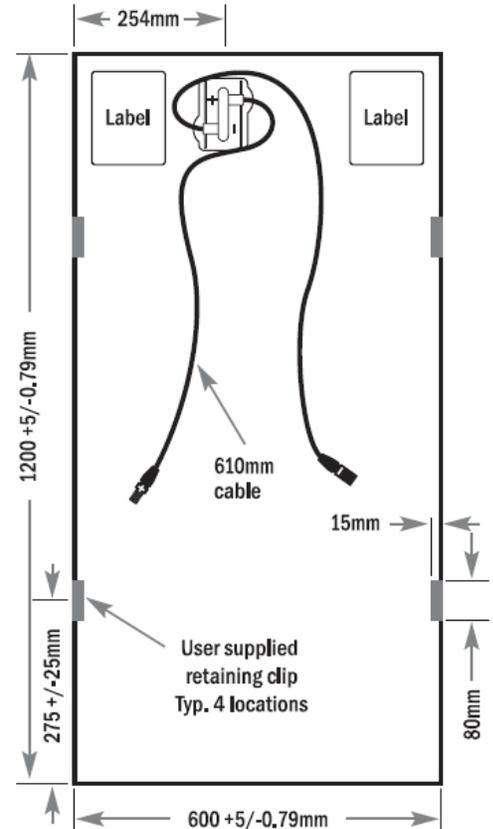
PV systems should be designed to comply with and provide module overcurrent protection consistent with local codes as appropriate for the intended application class of the system.

Please refer to FS Application Note PD-5-308 for additional information on module overcurrent protection.

## 5.0 Mechanical Specifications & Drawings

Table 5.1: Mechanical Specifications

Figure 5.1: Mechanical Drawing for FS Series 2 PV Modules



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## 6.0 Proper Operating Conditions

The proper operating condition requirements listed below must be maintained.

**Failure to maintain proper operating condition requirements for the modules will void the warranty (refer to First Solar FS Series Module Warranty Terms & Conditions PD-5-102).**

Requirements:

- First Solar must be notified in writing if modules are operated in open or short circuit conditions for more than 90 consecutive days during the installation period or any subsequent operating period; for modules operated in open or short circuit conditions for 90 consecutive days or longer, First Solar requires installers to use commercially reasonable efforts to grid-connect the modules as soon as practicable.
- All electronic components that are interconnected to modules must have an operating voltage window that matches the maximum power point of the array, and be capable of operating the array at the maximum power point at all times.
- All electronic components that are interconnected to modules must be rated for the maximum operating voltage of the array.
- Modules must have adequate ventilation and airflow to prevent excessive operating temperatures.
- Modules should not be shaded by obstructions at times of high irradiance (typically between 9:00am and 3:00pm).
- Modules should not be used in positive-grounded or bi-polar systems.
- Strain relief cable ties must not be removed.

## 7.0 Service



**Cleaning activities create risk of damage to the modules and array components, as well as the potential for electric shock.** Large amounts of dust and dirt on the surface of the module can reduce the power produced. Natural rainfall will typically remove most dust. Should auxiliary cleaning be required, please refer to the Module Cleaning Guidelines (PD-5-804) for additional information. Failure to comply with the Module Cleaning Guidelines may void warranty.



**Broken modules should be replaced immediately.** Periodically, annually at a minimum, inspect modules for any signs of damage or broken glass. If broken modules are found, place material into a closed container for return to First Solar recycling program, or dispose of module in accordance with local requirements. Please visit [www.firstsolar.com/recycling](http://www.firstsolar.com/recycling) for further details on the recycling program.

The most common causes of lower-than-expected PV system power output are:

- Inverter failure
- Improper or faulty field wiring or connections
- Blown fuses or tripped circuit breakers
- Excessive amounts of dirt and dust on the modules
- Shading of modules by trees, poles, or buildings
- Improperly calibrated or malfunctioning monitoring equipment

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## 8.0 Warranty Terms & Conditions

Please refer to, “First Solar FS Series Module Warranty Terms & Conditions” (PD-5-102) for warranty terms, limitations, and product return policies.

### Notice

Changes to certain components of the module are common as First Solar continuously strives for product improvements. Changes may be a result of component improvements or changes by a supplier, or by minor design modifications initiated by First Solar. All products within the same model classification remain functionally equivalent and fully compatible with one another, even though there may be slight differences. Modifications that do not impact the functionality of the product will typically be made without customer notification. Internal testing, and review or retesting by a certifying agency, will be completed before component or design changes are introduced into the manufacturing process.

First Solar reserves the right to make changes in solar module design and/or specifications at any time without notice. Accordingly, the reader is cautioned to verify that data sheets are current before placing orders. Information furnished by First Solar is believed to be accurate and reliable. However, no responsibility is assumed by First Solar or its subsidiaries for its use; nor for any infringements of patents or other rights of third parties which may result from its use. No license is granted by implication or otherwise under any patent or patent rights of First Solar or its subsidiaries.

In the event of a conflict between this module User Guide and the instructions of one of the system component manufacturers, the system component instructions should prevail.

For information regarding First Solar and its products, please visit [www.firstsolar.com](http://www.firstsolar.com)

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