

User Guide: Toledo Solar TS2-WS Module

North America

REV 0.0



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1 Introduction

Toledo Solar TS2-WS Modules are manufactured in state-of-the-art facilities using a highly innovative process that rapidly deposits thin films of semiconductor on glass. The modules have been designed to have a long operating life and high energy yield when installed, operated, and serviced in accordance with the instructions in this User Guide.

1.1 Before You Begin

This document provides guidelines and information on Toledo Solar TS2-WS modules of model 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 Toledo Solar TS2-WS. 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 applicable warranties.

This user guide pertains to modules installed within North America only. If a module is being installed outside of North America, contact Toledo Solar (info@toledo-solar.com) for the User Guide appropriate for other geographic areas.

Keep this User Guide for future reference.

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

1.2 Key Product Features

- High energy yields in real-world conditions.
- Size and weight that enables efficient handling and installation.
- Easy, quick-connect wiring for fast interconnection.
- Compatible with advanced 1500V plant architectures.
- Internationally recognized product certifications.
- Thirty year limited performance warranties.

1.3 Safety



The TS2-WS Modules may produce voltage up to 110 Volts DC (VDC) or current up to 3.0 Amps 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 system voltage to exceed 1500VDC 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 Toledo 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 practices as stated in this document 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 on non-interconnected modules or systems. Wear electrically rated PPE when working on interconnected modules or system components.

2 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 to the installation and use of Toledo Solar Suite Modules.

- Before beginning the PV system design and installation, contact appropriate local authorities to determine local code, permit, and inspection requirements.
- For systems installed in Canada, installation shall be in accordance with CSA C22.1, Safety Standard for Electrical Installations, Canadian Electrical Code, Part 1.

Toledo Solar TS Suite Modules are Listed by a Nationally Recognized Test Laboratory to UL 61730, 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 1500VDC (1000VDC for UL Canada).
- Install modules with mounting systems that have been evaluated for UL Listed application as specified in Toledo Solar Application Note TSI-PD-400-04 NA.
- Protect modules from reverse currents in excess of the Maximum Series Fuse rating of 4.0A.

When using MC4 connectors, TS2-WS Modules meet the requirements of Protection Class II for 600VDC systems and Protection Class 0 for 1000VDC systems. When using MC4-EVO 2 connectors, TS2-WS Modules meet the requirements of Protection Class II for 1000VDC and 1500VDC systems. TS2-WS Modules are tested and certified per IEC 61730 with maximum overcurrent protection ratings of 4.0A. TS2-WS Modules are tested and certified per IEC 61646 / IEC 61215 for a maximum system voltage of 1000V.

3 Electrical Specifications

Module Name	TS2-105		TS2-110		TS2-115		TS2-120	
	STC	NOCT	STC	NOCT	STC	NOCT	STC	NOCT
Maximum Power (P_{mp} , W) (-0/+5W)	105.0	78.9	110.2	82.4	115.0	85.9	120.0	89.9
Voltage @ Max Power (V_{mp} , V)	66.2	62.1	67.5	63.4	69.3	64.6	70.8	66.6
Current @ Max Power (I_{mp} , A)	1.59	1.27	1.63	1.30	1.66	1.33	1.69	1.35
Open Circuit Voltage (V_{oc} , V)	78.0	73.8	78.6	74.3	79.1	74.8	79.6	75.2
Short Circuit Current (I_{sc} , A)	1.82	1.59	1.83	1.60	1.83	1.60	1.87	1.60

Maximum System Voltage	1000 V
Safety Class	Class 0
Application Class	Class B
Fire Rating	Type 3
Temperature Coefficient of P_{mpp}	-0.28% / °C (from 25° C to 75° C)
Temperature Coefficient of V_{oc}	-0.28% / °C
Temperature Coefficient of I_{sc}	+0.04% / °C
Efficiency at 200W/m ²	2% greater than efficiency at 1000 W/m ²
Normal Operating Cell Temperature (NOCT)	45°C
Limiting Reverse Current (I_r)	4A
Maximum Source Circuit Fuse (I_{CF})	4A

1. Class A Spread of Flame / Class C Burning Brand. Roof mounted fire rating is established by assessing rack and solar module as a unit
2. Limited power output and product warranties subject to warranty terms and conditions
3. Ensures 98% rated power in first year, -0.5%/year through year 30
4. All ratings \pm 10%, unless specified otherwise. Specifications are subject to change
5. Measurement uncertainty applies
6. Application Class A for 600V (class II), Application Class B for 1000V (class 0) with MC4; Application Class A for 600V and 1000V (class II) with MC4-EVO
7. Multi-Contact: MC4 (PV-KST4/PV-KBT4) MC4 EVO 2 (PV-KST-EVO 2 / PV-KBT-EVO 2).
8. Higher load ratings can be met with additional clips or wider clips, subject to testing

3.1 System Derating Factors

Under normal operation, a photovoltaic module may experience conditions that produce more current and/or voltage than reported at Standard Test Conditions. Accordingly, the datasheet and label specification values listed for STC should be multiplied by a factor of 1.25 for voltage and current when determining component ratings. Adjustments of those factors might be needed to respect site specific climate conditions. As defined in the National Electric Code and IEC 62548, the maximum system voltage for a Photovoltaic System is determined using the open circuit voltage of the PV modules.

4 Installation

4.1 Mounting



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



Do not install the modules during 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.

- Handle modules with care during installation, as heavy impact on the front, back, or edges could result in damage to the module. Do not walk or stand on modules or retaining clips.
- 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 to minimize the risk of wire damage.

Mounting of the TS2 Module to a suitable structure can be done by attaching the module directly to the structure using retaining clips (see Figure 5.1).

Any module without a frame (laminates shall not be considered to comply with the requirements of UL 1703 unless the module is mounted with hardware that has been tested and evaluated with the module under this standard or by a field inspection certifying that the installed module complies with the requirements of UL 61730. The TS2-WS Module is a frameless laminate and is considered to be in compliance with UL 61730 only when the module is mounted using approved hardware in the manner specified by the mounting instructions in Toledo Solar Application Note TSI-PD-400 04.

Additional mounting systems may be approved for use. The interface of the mounting structure to the module (including the retaining clip and rubber insulator) must meet the technical requirements specified in Toledo Solar Application Note TSI-PD-400-04 and must be approved for use by Toledo Solar prior to installation. The mounting system design must provide adequate support for the module to prevent damage from occurring when the module is subjected to pressures of 2400Pa (which equates to wind pressure of 130km/h (80.8 mph), with a safety factor of 3 for gusty conditions based on IEC 61646 / IEC 61215). The location of the clips shall be along the 1200mm (47.25 in) length of the module and the center point of the clip shall be located between 250mm (9.84 in) and 300mm (11.81 in) from the module edge. See Figure 5.1 for allowed location. Rubber insulator material, or equivalent must be used between the module and both the clip and mounting structure to provide adequate protection of the module and must meet all requirements described in TSI-PD-400 TSI Module Mounting. Clamps must be bolted with a torque of 50 in.-lbs. No direct contact of rigid structures is permitted against the surface or edges of the module.

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 underside of the module. Modules generate heat and require adequate airflow for cooling.

Installation locations and module support structures should be selected to ensure modules and connectors (open or mated) are never submersed in standing water. Toledo Solar modules are tested and certified for applications involving pressures from snow/ice/wind up to 2400 Pa (50.13 lb/ft²) when mounted properly. Snow drifts could result in a nonuniform loading of the modules which exceeds the tested pressure. If it is expected that loads will exceed 2400 Pa (50.13 lb/ft²), it is recommended to clear snow from modules, and ensure that ice/thaw/freeze cycles under snow drifts do not result in excessive stresses on the module.

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

Ensure any site preparation or maintenance chemicals (soil binding agents or chemicals used for on-site dust control or weed control) do not spray, splash, or drift onto the surface of the modules or its associated components.

The UL approved design load of TS2-WS Modules is 30 lb/ft² (1436 Pa).

Maximum allowable pressure on modules may not exceed 2400 Pa (50.13 lb/ft²) without additional module support that must be tested and approved by Toledo Solar to receive a project specific approval.

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 (82.55 mm). Modules used in UL Listed rooftop applications must be installed with approved mounting systems. If alternate mounting means are employed, this may affect the Listing fire class ratings and additional UL fire testing may be required. The fire rating of this module is valid only when mounted in the manner specified in the mechanical mounting instructions.

4.2 Module Orientation

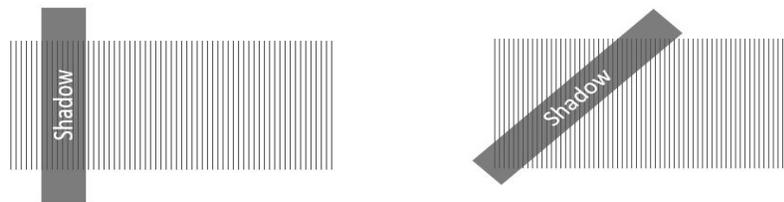
PV performance modeling software should be used to determine the optimum orientation and tilt angle for each location.

For tilted free-field applications or single-axis tracker applications where there is row to row shading, modules shall be installed in landscape orientation.

4.3 Module Shading Considerations

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.). Installation must avoid locating the modules where shadows may be caused by buildings, trees, etc.

Specific shading patterns can cause damage to module cells due to the creation of localized areas of reverse bias. Reverse bias is generated by one or more series-connected cells being shaded while the rest of the cells are fully illuminated. When shading geometry is suitable for damage to occur, it can happen in very short durations (seconds to minutes) and under a wide range of irradiance (as low as 160 W/m²). An example of prohibited shading orientation is presented below.



There is no risk of module damage due to “row-to-row” shading in landscape orientation. There is also no risk if shading occurs while modules are in open circuit conditions or no risk from diffuse shading for objects greater than 2 meters or 7 feet.

There is a risk of module damage due to shading from walking or standing in front of operating modules or from parking or driving vehicles in front of operating modules during illuminated times. Best practice is to stay close to the back side of the adjacent rack as one travels down a row of operating modules.

Instances of shading that will lead to a voided warranty include the High Risk items listed below.

High Risk (Prohibited) Shading

1. Resting or adhering slender objects (tools, brooms, clothing, wires, tape) on sunny side of operating modules, or when nearer than ~5-7 feet above operating modules, especially when shadow oriented parallel to cells.
2. Fixed objects within ~5-7 feet above operating modules that cast a shadow over the long dimension of the cells. Close objects like posts, ropes, signs, fences, or equipment can begin to increase risk of partial shading of full cells when nearer than ~5-7 feet from the sunny-side of operating module.
3. A support frame or mounting method on the short edge(s) of modules that fully shades the entire length of a cell (either partially or completely).
4. Working continuously with outstretched arms or tools over operating modules.
5. Cleaning apparatus, including cleaning robots and other mechanisms that traverse the module repeatedly while the system is operating (unless evaluated and approved by Toledo Solar).

4.4 Electrical Interconnection

Toledo Solar 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 cables and MC4 connectors are UV and weather resistant from -40°C to $+85^{\circ}\text{C}$, and rated for 1500VDC and 22.5A (minimum, before derating for ambient temperature). The cables and MC4-EVO 2 connectors are UV and weather resistant from -40°C to $+85^{\circ}\text{C}$, and rated for 1500VDC Protection Class II applications and 39A (ambient temperature).



Modules with different TS Suite designations (i.e. SS(LV) vs. WS(HV) have significantly different electrical operating characteristics and should not be interconnected within the same inverter or MPPT to prevent power output loss and voltage imbalance conditions that may create the risk of reverse current overload.



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.**
- **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 minimum module lead wire bend radius is 5 times wire diameter. Observe minimum bend radius specifications on all other PV system wiring.**
- **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.**

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 rated for 90°C , and be of a type approved for use in accordance with the NEC.

Module-to-module and module-to-harness interconnection is advised to be done between same manufacturer and type of connectors or using connectors certified as mateable. The Toledo Solar module warranty is not affected by the interconnection of different supplier connectors, however, Toledo Solar cannot guarantee that different connector types will be mateable in every connection instance.

Connector Identification

MC4 connectors of part numbers (PV-KST4/PV-KBT4)



MC4-EVO 2 connectors of part numbers (PV-KST-EVO2/PV-KBT-EVO2)



Connector manufacturer website: <http://ec.staubli.com/>

4.4.1 Inverter Compatibility

TS Suite Modules are designed for utility grid connected, residential, commercial and industrial, off-grid energy access, and fuel displacement applications. Toledo Solar TS Suite PV Modules are compatible with a range of string, central, and transformer less inverters. When connecting modules or module strings in series ensure inverter ratings are appropriate.

When connecting Toledo Solar Modules in a series string, ensure that the system design voltage and inverter design specifications are not exceeded. For 1000VDC applications, this is typically ensured by limiting series strings to 10 modules or less. For 1500VDC applications, this is typically ensured by limiting series strings to 15 modules or less.

The Maximum Power Point (MPP voltage of a module array must be considered for compatibility with the specified MPP window of the inverter. Similar to the maximum open-circuit voltage, the MPP voltage of the array is dependent on ambient conditions, and the system should be designed to ensure that the MPP voltage of the array remains within the MPP window for expected operating conditions.

When selecting an inverter, system bias conditions and grounding should also be considered. TS Suite PV Modules can be used in negative-grounded or ungrounded installations. Use in bi-polar systems should be reviewed in detail by Toledo Solar prior to approval. TS Suite PV Modules should not be used in positive-grounded systems.

4.4.2 Grounding Method

Per the requirements of UL 61730, a module with exposed conductive parts is considered to be in compliance with UL 61730 only when it is electrically grounded in accordance with the instructions presented and the requirements of the National Electrical Code.

Toledo Solar TS2-WS Modules have no exposed conductive surfaces and do not require equipment grounding as long as a clip length of 100mm for a standard 4 clip mounting is not exceeded. In the U.S., the mounting structure must be grounded per the requirements of the NEC, sections 250 and 690.

Toledo Solar TS2-WS Modules can be used in negative-grounded, ungrounded, floating, and bi-polar system architectures, provided all appropriate design requirements are met and approved by Toledo Solar. TSI Series PV Modules should not be used in positive-grounded systems.

4.4.3 Overcurrent Protection

TS2-WS Modules have a maximum series fuse rating of 4.0A as defined by UL 61730 test methods.

TS2-WS Modules have a maximum overcurrent protection rating of 4.0A 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.

Connection of parallel strings must incorporate measures to protect modules against reverse currents exceeding their rating.

5 Mechanical Specifications & Drawings

Table 5.1: Mechanical Specifications

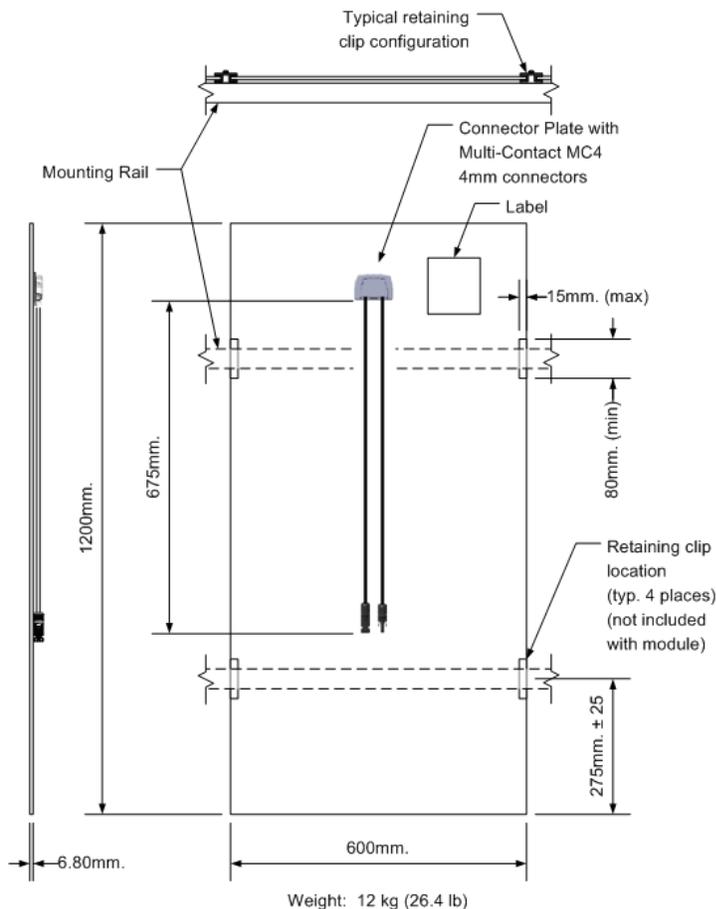
Specifications	TS2-WS Modules	
Length	1200 mm	47.25 in
Width	600 mm	23.63 in
Thickness	6.8 mm	0.27 in
Total Area	0.72 m ²	7.75 ft ²
Individual Leadwire ¹	675 mm	26.57 in
Leadwire Connection Span ²	1350 mm	53.14 in
Weight	12 kg	26.5 lbs
Fire Performance Type ³	Type 3 Module Class A Spread of Flame Class C Burning Brand	
Operating Temperature	-40°C to +85°C	

¹Minimum from strain relief to connector mating surface

²Minimum from positive strain relief to negative strain relief of adjacent module

³Roof mounted fire rating is established by assessing rack and module as a unit

Figure 5.1 Mechanical Drawing for TS2-WS Modules



6 Proper Operating Conditions

The proper operating condition requirements listed below must be maintained.

Important: Failure to maintain proper operating condition requirements for the modules will void the applicable warranties.

Requirements:

- Short circuit operation is permitted only during short duration system safety testing or in fail-safe system states.
- All electronic components that are interconnected to modules must be rated for the maximum operating voltage of the array, must have an operating voltage window that matches the maximum power point of the array, and must be capable of operating the array at the maximum power point.
- Modules must have adequate ventilation and airflow to prevent operating temperatures above 85°C.
- Module row-to-row shading in landscape orientation is acceptable; Module row-to-row shading in portrait orientation is prohibited.
- If module cleaning is undertaken, modules must be cleaned only when in open circuit – either disconnected from load, or during times when inverter is turned off and otherwise in accordance with "PV Module Cleaning Guidelines".
- Module boxes must be handled per Box Handling and Storage. Failure to follow the Box Handling and Storage guidelines may result in damage to modules that would not be covered under the Module Warranty Terms and Conditions.

7 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, modules must be disconnected and in open circuit. Do not use abrasives, harsh detergents or high pressure to clean modules. Failure to comply with these 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 Toledo Solar recycling program, or dispose of module in accordance with local requirements. Please visit www.toledo-solar.com/recycling for further details on the recycling program.

- It is normal for the modules to exhibit visual irregularities which do not impact power.
- Check that all electrical connections are tight and corrosion free.

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

8 Warranty Terms & Conditions

Please refer to Toledo Solar for individual module warranty terms, limitations, and product return policies.

9 Notice

Changes to certain components of the module are common as Toledo 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 Toledo Solar. All products within the same model classification remain functionally equivalent and fully compatible with one another, even though there may be slight differences, provided appropriate system design practices are employed. 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.

Toledo 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 or finalizing system permitting and/or design. Information furnished by Toledo Solar is believed to be accurate and reliable. However, no responsibility is assumed by Toledo 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 Toledo 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 Toledo Solar and its products, please visit www.toledo-solar.com. For technical support, please contact info@toledo-solar.com.

Global

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10 Document References

Document Number	Document Title
TSI-PD-400-04	TSI PV Module Mounting
TSI-PD-400-05	TSI Box Handling and Storage

11 Revision History

Revision Number	Amendment Detail	Revision Date