Installation and Operations Manual for

Clarity Monitors – SPM80V12A, SPM80V12A-S

SPM125V8A, SPM125V8A-S

Clarity Site Server – SPS1

Clarity Gateway – SPG1

Clarity Disable Switch – SPD1

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Section 1– Important Safety Instructions/Read this First

PLEASE SAVE THESE IMPORTANT SAFETY INSTRUCTIONS

This manual contains important instructions for the installation, commissioning, operations and maintenance of Solar Power Technologies, Inc. (SPTI) Clarity Monitors: SPM80V12A; SPM80V12A-S; SPM125V8A; SPM125V8A-S; and related support equipment. Please read thoroughly before attempting installation.

- *Only qualified personnel should install, replace or service the Clarity Monitors. SPTI will not be liable for loss or damage due to improper installation or misuse.*

- *Tampering with or opening the Monitor, Gateway, Disable Switch or Site Server creates an electrical shock risk and will void the warranty. Do not attempt repair, these units contains no user-serviceable parts.*

- *Do not connect or disconnect the Monitors while under load: both DC and AC power must be disconnected from the PV system inverter before installation or servicing. To further ensure safety, it is highly recommended that all combiner box fuses be removed, prior to Monitor installation.*

- *When unloaded, both the Monitor and its adjacent PV panel still present a shock risk: note that the Monitor's output voltage will be as high as the PV panel's open circuit voltage (Voc) and any terminal may be as high as 1000V with respect to ground, depending on site design and wiring connections*

- *Under extreme environmental conditions, a photovoltaic panel may produce higher short-circuit currents and/or higher open-circuit voltages than specified by the panel's nameplate Standard Test Condition (STC) rating. Accordingly, these higher values of Isc and Voc should be utilized when determining compatibility with the Monitor's maximum current and maximum voltage specifications.*

- *Electrical installations must be carried out in accordance with all local electrical codes; the National Electrical Code (NEC), ANSI/NFPA 70; and with any other codes and regulations applicable to your installation site.*

- *Refer to Section 9 of this document for Warranty Terms and Conditions. Contact SPTI customer service at support@spowertech.com for return approval and RMA* number.

Section 2 - Product Compliance Information

Safety

The SPM80V12A, SPM80V12A-S, SPM125V8A, SPM125V8A-S, SPG-1 and SPD-1 are currently undergoing certification to the appropriate and applicable sections of the following International Standards:

- UL 60950-1: *UL Standard for Safety Information Technology Equipment – Part 1: General Requirements*
- CSA C22.2#60950-1 *Information Technology Equipment Safety Part 1: General Requirements-First Edition; IEC 60950-1:2001, MOD; UL60950-1; Update 1; Update No2: 07/2006*
- IEC 60950 : Issued 1991/09/01 Ed:2 Safety of Information Technology Equipment, Including Electrical Business Equipment Amendment 1-1992; Amendment 2-1993; Amendment 3-1995; Amendment 4-1996

All versions of the Monitor, SPG-1 and SPD-1 enclosures are watertight and comply with the NEMA 4 / IP 65 environmental enclosure rating standard.

FCC Part 15 Compliance

This equipment has been tested and found to comply with the following requirements

- FCC 47CFR Part 15.247 Operation within the bands 902-928 MHz, 2400-2483.5MHz and 5725-5850 MHz
- FCC 47 CFR 15B Class B verification
- ETSI EN 300 328 ; Issued 2007/01/09 V1.7.1 Electromagnetic compatibility and radio spectrum matters (ERM); Wideband transmission sys; data transmission equipment operating in the 2.4 GHz ISM band & using wideband modulation techniques; Harmonized EN Article 3.2
- ETSI EN 301 489-1; Issued 2008/04/01 V1.8.1 Electromagnetic compatibility and radio spectrum matters (ERM); Electromagnetic compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements
- ETSI EN 301 489-17; Issued 2009/05/12 Electromagnetic compatibility and radio spectrum matters (ERM); Electromagnetic compatibility (EMC) standard for radio equipment; Part 17: Specific conditions for broadband data transmission systems – V2.1.1

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and the receiver.
- Connect the equipment into an outlet different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Changes or modifications made to the equipment not expressly approved by SPTI may void the user's authority to operate the equipment. This device does emit Radio Frequency (RF) energy when powered up. To limit exposure to this RF energy, the user should keep a distance of 20 cm from the device.

Section 3 – Product Overview

3.1 Clarity Monitor

Attached to each panel in a PV array, the Clarity Monitor units continually measure real-time panel performance, providing insight into large-scale arrays with an unprecedented level of precision and detail. The small, easy to deploy units, organize themselves into a dynamic wireless mesh network, forwarding real-time array performance data through the SPG-1 Wireless Gateway to the Clarity Intelligent Array site management system. After capturing panel performance data, the site management system then analyses and detects panel-level, string and/or area impairments that are adversely impacting energy production, and then recommends actions to maintain the array at peak performance.

Site owners and maintenance teams now have the tools to pinpoint panel damage, wiring faults, blown fuses, and the effects of panel soiling and aging on energy production. This information simplifies and streamlines Operations and Maintenance (O & M) processes, including array troubleshooting, prioritizing high impact maintenance, cleaning schedules, and identifying potential product warranty claims.

For maximum insight, a Monitor is deployed on every PV module in an array. However, it is possible to trade off detailed insight for cost by selectively deploying Monitors across the array on a subset of the PV modules. If at least one panel in each string is fitted with a Monitor, the entire array is enabled with a cost effective string monitoring system, with the added benefit of panel degradation and soiling analysis on those panels fitted with a monitor. Note that in all deployments and especially partial deployments, care must be taken to ensure the continuity of the mesh communications network. This will depend on site specific factors, but it is recommended that in partial deployments, Monitors be evenly distributed throughout the array and the distances between Monitor be kept to less than 20 yards.

There are 4 versions of the Monitor:

- SPM80V12A: typically used with crystalline PV panels (Voc <80V)
- SPM80V12A-S: same as above, equipped with Disable Switch option
- SPM125V8A: typically used with thin-film PV panels (Voc < 125V)
- SPM125V8A-S: same as above, equipped with Disable Switch option

The optional Disable Switch control feature noted above, allows for remote DC disconnect of individual panels where unsafe behavior has been detected (e.g. arcing), for maintenance, repair, or complete array shutdown (“Emergency Stop”).

Clarity Monitors are designed to be compatible with all makes of PV panels and inverters, provided that the absolute maximum ratings of the Monitors are not exceeded. Additionally, their ‘non-intrusive’ design ensures that energy production will not be interrupted in the event of inadvertent electrical damage or failure of the units. Detailed technical specifications for the 4 products noted above are provided in Section 9 of this document.

3.2 Clarity Intelligent Array

Core to the Clarity system is the Intelligent Array software suite, a cloud based environment for maximizing site performance. The Intelligent Array understands the array down to the individual panel level and continually performs analysis and diagnostics on panel and string level data to identify array impairments and recommend remedial action to maintain optimal array performance. The system informs the owner and O&M teams precisely what where and how action is required to maximize site ROI based on financial rules set by the owner.

Key to the operation and accuracy of the Intelligent Array is the Site Definition Map, which contains information regarding the physical assets deployed throughout the array, including performance specifications, hierarchical connection and physical location. This is created as a part of the commissioning process and is covered in Sections 4 and 6.3. The Intelligent Array utilizes cloud-based computing. This distributed computing approach minimizes on-site computing hardware and software, lowering on-site equipment cost and eliminating the complexities associated with hardware operation, maintenance, or software upgrades.

Two on-site components are required to enable communication with the Monitors, collection of panel and other site data and communications with the cloud based resources: the *SPTI Gateway (SPG1) and the SPTI Site Server (SPS1),* which are described below.

The SPG1 wireless gateway acts as the communications hub for the network of Monitors. It captures information from the mesh network in real-time, and forwards that data to the site server. The Site Server performs initial data reduction and error check on the data stores a copy in its local memory for short term backup purposes, and then forwards the information to the cloud-computing environment, via a secure Internet interconnection.

The Site Server also acts as an environmental monitoring station. In its standard configuration, it comes equipped with the following environmental sensors

- *Irradiance*
- *Ambient Temperature*
- *Panel Temperature*

These environmental sensors are an important element of the Intelligent Array, enabling comprehensive performance analysis normalized for local climatic conditions. The outputs of these sensors are monitored in real time then synchronized with the Monitor data for both local storage and for use by the Intelligent Array software tools for performance analysis.

Installation of these sensors is covered in Section 5.4.

Section 4 –Intelligent Array Definition

4.1 Site Documentation Map

The Clarity Intelligent Array utilizes a broader dataset than existing PV system monitoring and management solutions, enabling pinpoint accuracy with regards to fault identification and physical fault location. This dataset is captured in a Site Documentation Map (SDM), which is detailed below.

The SDM describes the array's DC electrical hierarchy plus the physical location of individual panels, strings, combiners and inverters. The Clarity Intelligent Array site management system merges these structured representations of electrical design (from 1-line design documentation and engineering drawings), and physical location (from "as built" documentation and/or site photography), to perform comprehensive performance analysis, comparisons to expectations and precise localization of suspected impairments and recommended maintenance requirements

The Site Documentation Map is best built using a bottom up approach. Each installed Panel Monitor is identified by: 1) its unique serial number/mac address; 2) its input port PV panel serial number; and 3) its unique string ID and position "N" in that string. To ensure consistent documentation, position "1 of N" is always defined as the most negative voltage string position (negative output port of Panel Monitor wired to combiner box); "2 of N" the second most negative position; and position "N" as the most positive string position (positive output port of Panel Monitor wired to combiner box).

Once strings are defined as described above, groups of strings are then "connected" with combiner boxes, and combiner boxes are then associated with Inverter ID and related DC bus-bar location. By documenting these associations, we are building a complete hierarchical and spatial relationship for the PV array, containing:

1) PV Panel (serial number) plus its associated unique Monitor (serial number/mac address) – serial numbers may be captured during Monitor install, however we highly recommend that other associations noted below be pre-defined
2) Unique String ID and position "N" in String;
3) Associated Combiner Box ID and Combiner Port ID;
4) Associated Inverter ID and DC bus-bar location
5) Actual physical location of each element noted above, from "as built" documentation, or site photographs.
6) Component inventory: brand and model number of PV Panels, Combiners and Inverters utilized in the Array.

Solar Power Technologies has standard templates available that simplify capturing data relationships for both the DC wiring topology, and the physical array layout. Forward your site technical documentation to support@spowertech.com: subject line should include your "site name – please create my SDM", body of email should contact information and any pertinent comments regarding your Array design.

SPTI's application engineers will create an initial SDM and preload the Intelligent Array database with this site-specific information for your review, prior to final system commissioning.

This initial SDM data build will typically include the following:

- *Site name and location*
- *Site owner/operator name and contact info*
- *Users and roles*
- *DC array size (total STC Watts)*
- *Physical array layout and DC wiring plan, including inverter home runs*
- *DC string count, string length and string physical location*
- *PV panel make and model*
- *Combiner and sub-combiner box make and model*
- *Inverter make and model*
- *Design assumptions, including working and open string voltages and maximum string currents*
- *Other monitoring system (Inverter-based or 3rd party) make and model*
- *Proposed Panel Monitor, Site Server and Gateway install date(s)*
- *Proposed commissioning date*

Note that larger installations may require more layers of definition in the SDM, such as sub-combiners, sub-arrays or multiple inverters. The Intelligent Array data model supports this additional hierarchy. For specific requirements not covered within the SDM templates provided, please contact support@spowertech.com.

For new systems, this initial SDM may not reflect physical component location, that data can be added, post construction. For retrofit, as well as new applications, as-built documentation and site photographs should be used to create an accurate database. Note that an accurate SDM ensures that the Intelligent Array Management Suite delivers the best and most precise fault identification and analytics at initial commissioning.

An incomplete, or inaccurate SDM does not prohibit monitor operation, however the SDM should be updated as necessary to accurately reflect the actual status and configuration of the array.

Our applications engineers will assist you with SDM updates as necessary; details on the use of our Intelligent Array Management Suite and its SDM-specific graphical-user interface ("GUI") are provided in our Intelligent Array User Guide.

Section 5 – Site Server, Wireless Gateway and Sensor Installation

5.1 Site Server Installation

For planning purposes, please read this entire section before installing the Site Server. Then mount the Site Server in your best and most appropriate location, after considering all of the variables noted below.

Site Server Enclosure

The Site Server utilizes a 16” x 14” x 8” NEMA-6 composite (non-metallic) enclosure with a lockable front door, and is shipped with the following contents packed inside:

- Mounting brackets for Server (wall or uni-strut attachment)
- 10 feet AC grounded power cord
- 10 feet RJ-45 cable for broadband Internet connection
- 50 feet RJ-45 cable for Gateway connection
- Irradiance sensor with mounting clip, and 50 feet shielded, low-voltage interconnect cable
- “One Wire” ambient temperature sensor with 50 feet shielded low-voltage interconnect cable and mounting hardware
- “One Wire” cell temperature sensor with 50 feet shielded low-voltage interconnect cable and mounting
- Cable glands for all of the above

Upon receipt, unpack and verify that the Site Server arrived and that all components noted above arrived undamaged, contact your supplier or support@spowertech.com

immediately regarding any noted shipping damage, or missing components.
Each of the UV-resistant low-voltage interconnect cables provided utilizes its own cable gland, or the installer may elect to use separate conduits for power, sensors, and network connections. If the cable glands are used, each gland must be located in the base of the Site Server's enclosure to ensure a long-term watertight and weatherproof connection. Allowable penetration regions for cable glands (bottom) and/or conduit (top and bottom) are indicated by labels on the enclosure's interior, and must be observed by the system installer. Any enclosure penetration made outside of these designated areas will immediately void the Site Server's warranty. Take care when drilling through or mounting the enclosure, to avoid damaging internal electronic components.

The Site Server requires 120V or 240V AC power (dependent on region) and a broadband Internet connection, and although weatherproof, we recommend it be mounted in a shaded, relatively dry, and readily accessible location. Adjacent to the central inverter, or a bank of string inverters is often an ideal location; however, while locating the Site Server, also consider the ease of mounting and routing the wiring of the 3 environmental sensors, as well as Internet and Gateway cabling.

Site Server Internal Layout

Do not power up the Site Server until all external wiring is completed: this includes the Internet connection, irradiance and temperature sensors, and gateway cabling.

- *There are no user-serviceable components within the Site Server. Any modification of, or tampering with the internal wiring and components, other than the connections noted above will immediately void the warranty*

5.2 Broadband Internet Connection

Broadband Internet connectivity is the responsibility of the system installer and/or site owner. The provided RJ45 Ethernet cable should be plugged from your router or hub into the top/right-side port labeled “LAN”, on the rBox104 Industrial Computer, located inside the Site Server Enclosure.

rBOX104 Industrial Computer

If a wired broadband connection is not readily available, consult with our applications engineering team to determine appropriate wireless broadband alternatives. A 120V (or 240V dependent on region) courtesy outlet is provided inside the enclosure to accommodate wireless routers or other ancillary networking equipment as necessary. Do not use this outlet to power tools, or other high-current AC devices.

5.3 Gateway Installation

The Gateway is housed in a small UV-resistant enclosure, with a weatherproof, bayonet-style Ethernet cable connector. The Gateway and its associated Ethernet-cable installation hardware are shipped independently of the Site Server. The physical mounting of the Gateway is the responsibility of the installer. Additional guidelines for installation are detailed below.

Gateway with Weatherproof Ethernet Connector

The Gateway serves as the Array radio transmitter/receiver, communicating with and collecting data from each Monitor and/or Optimizer, or node, via the mesh network, and then returning all data collected to the Site Server, using a dedicated Ethernet cable connection. The Site Server powers the Gateway remotely, using PoE (Power over Ethernet), allowing the Gateway to be located up to 100 meters distant from the Site Server with no other source of power.

For best performance, the Gateway should be located at an edge of the Array within 10 feet of the nearest Monitor and/or Optimizer and oriented in generally the same plane as the Monitors and/or Optimizers. Use self-tapping sheet metal screws through available holes in the base of the Gateway to simplify installation to panel frame rails, or other convenient mounting structures.

Due to the nature of the mesh network communications mode, one gateway will handle a network of several thousand nodes. It is possible, however, and often desirable to add additional gateways for fault tolerance or to improve data collection performance. For large and complex sites, multiple Gateways may be required, based on the physical layout, as well as on node count. Contact the SPTI technical support line at 800-fix-mysolar or email *support@spowertech.com* with questions regarding optimal Gateway location or network coverage.

To connect the Gateway after installation, the provided RJ45 Ethernet Gateway cable should be terminated with the included field-installed RJ45 connector (instructions for installation of this connector are included with the connector) and ferrite bead (see installation instructions below), connected to the Gateway, then plugged into the POE Port #1, on the rBox104 Industrial Computer, located inside the Site Server enclosure. The SPTI-provided Gateway Ethernet cable is 50 feet long. The system installer is responsible for sourcing longer cables, should they be required. Note that there are existing connections pre-configured within the Site Server. Do not disturb these factory connections.

The installation procedure for the included ferrite bead is as follows:

Open the ferrite bead and lay the Ethernet cable in the bead as close as is convenient to the field-installed RJ45 connector. Close the bead, ensuring that the latch is engaged. A good practice is to secure the bead in place along the cable to prevent the bead from sliding away from the connector. This can be done with the provided plastic cable tie.

Ferrite Bead Installation

5.4 Irradiance and Temperature Sensor Installation

Install the irradiance sensor in an un-shaded area, preferably on the trailing edge of a PV panel within the array. Use the provided mounting hardware to match PV Array tilt and orientation. Typical mounting instructions are packed with the sensor, or the system installer may elect to fabricate a custom bracket.

Irradiance Sensor

To simplify wiring homeruns, we recommend that the cell temperature sensor be installed on the same panel as the irradiance sensor. The cell temperature sensor is supplied with a mounting bracket and adhesive, and should be mounted on the backside of the panel noted. Use UV-resistant wire-ties to secure irradiance and cell temperature wiring back to the Site Server. Some installers may elect to route these 2 low-voltage sensors thru conduit, in lieu of exposed wire.

Cell and Ambient Temperature Sensors

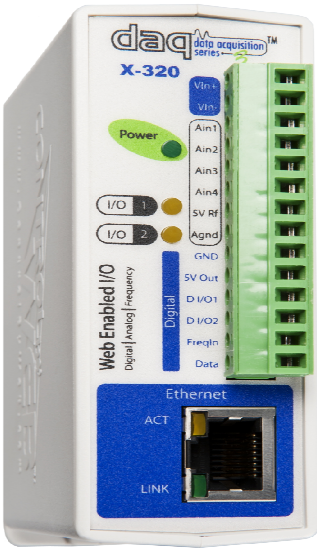
The 2 Temperature Sensors are labeled and identified as follows:

- Solar Power Technologies
- OW-TEMP-B3-50A
- 16 digit unique serial number,
- 0.5 inch orange shrink-wrap collar (identifies the ambient sensor)
- 0.5 inch red shrink-wrap collar (identifies the cell sensor)

Record both serial numbers, as they are important to the Site Server pre-commissioning process. Mount the ambient temperature thermocouple in a shaded location, where it can experience typical airflow, and route its cable back to the Site Server, as described above. If the Site Server is already located in a shaded area, that same space is usually ideal for the ambient temperature probe.

Both Temperature Sensors, as well as the Irradiance Sensor are wired directly the Control-By-Web X320 Control and Instrumentation Module, located in the Site Server. A small flat-headed screwdriver and wire-strippers will be required to make up these connections.

X320 Control and Instrumentation Module



The Irradiance Sensor is connected to 3 terminals on the X320, using the green terminal block shown in the image above: the sensor's white wire, connects to location

“5V Ref”; the sensor’s clear wire is connected to location Agnd; and the green wire should be connected to Ain1.

The Cell and Ambient Temperature Sensors are also connected to the X320, and they share a common connection: both blue wires are connected in common to Data, and both white wires are connected to Gnd. Note that there is already an Ethernet Cable between the X320 and the rBox104, as well as DC power connections. Do not disturb these factory connections.

5.5 Optional - Installation of SPD1 Clarity Disable Switch

The Clarity Disable Switch is an optional feature, utilized only within arrays that feature the SPM80V12A-S or SPM125V8A-S Monitors, which have the Disable Switch option installed. The SPD1 Disable Switch is housed in a small UV-resistant enclosure, with a waterproof Ethernet cable connector, identical to the Gateway Enclosure, with one important addition: it features an external “array off” button.

The Disable Switch and hardware is shipped independently of the Site Server. The Disable Switch is a remote disconnect switch that should be centrally located, yet installed in a secure location. Access to this Switch should generally be limited to O & M personnel, safety staff and/or array managers. Once the Switch is installed, the provided RJ45 Ethernet cable should be plugged into the POE Port #2, on the rBox104 Industrial Computer, located inside the Site Server Enclosure. The SPTI provided Ethernet cable is 50-feet long. The system installer is responsible for sourcing longer cables, should they be required.

5.6 Pre-Commissioning of Site Server

Prior to the install of Monitors, we recommend that the Site Server be pre-commissioned. This simple pre-commissioning sequence will test and validate basic functionality of the following Components:

- Site Server
- Wireless Gateway
- Environmental Instrumentation
- Optional Disable Switch
- Broadband Internet Connectivity
- Intelligent Array Cloud Computing Connectivity

Once steps, 5.1 through 5.5 have been completed, power up the Site Server by plugging in its 120V AC power cord. The rBox104 computer should immediately startup, and its power indicator light will be green within 60 seconds of power on.

Once the system is booted up and Internet connectivity verified, call our technical support line at *800-fix-mysolar*, or email *support@spowertech.com*: and via our cloud computing connection, our technical support team will then further validate the Site Server’s functionality including testing the three installed environmental sensors, and verifying the Site Server to Gateway communications link.

Section 6 – Monitor Installation

Review Section 1 of this document before attempting Monitor installation.

6.1 Monitor Mounting

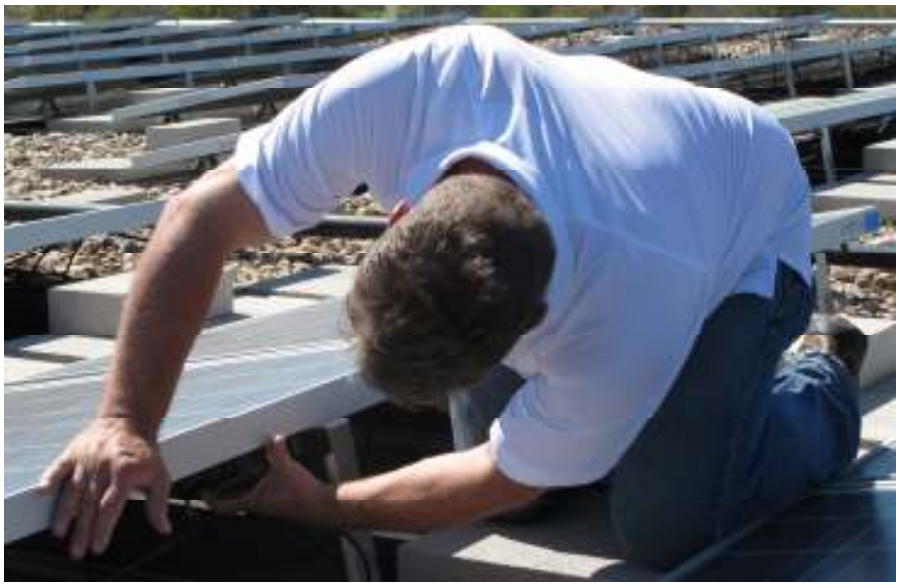
- *Do not connect or disconnect the SPM80V12A, SPM80V12A-S, SPM125V8A, or SPM125V8A Monitors while under load: both DC and AC power must be disconnected from the inverter; and all combiner box fuses must be removed prior to installation or servicing.*

- *When unloaded, each monitors and its adjacent PV panel still present a shock risk: the unit's output voltage is equal to the PV panel's open circuit voltage (Voc) and any terminal may be as high as 1000V with respect to ground, depending on site design and connections.*

- *Under extreme environmental conditions, a photovoltaic panel may produce higher short-circuit currents and/or higher open-circuit voltages than specified by the panel's nameplate Standard Test Condition (STC) rating. Accordingly, these higher values of Isc and Voc should be utilized when determining compatibility with the Monitor's maximum current and maximum voltage specifications.*

The Monitor enclosure is designed for direct mounting on the PV Panel frame rail, adjacent to the PV Panel's J-Box. The enclosure is secured to the frame rail via 2 integral spring steel clips, with the label facing down: no special tools are required for installation. Also note that the plastic molded enclosure is non-conductive, and does not require a separate ground wire or strap.

Clipping Monitor Enclosure to Frame Rail



Mounting each Monitor centered and under the PV panel protects it from direct exposure to sunlight, orients the internal antenna for optimum wireless connectivity and will ensure that its enclosure, power cables, and connectors are in a position where they are not easily damaged or become an obstruction to service and maintenance personnel.

The Monitor enclosure features integral MC4-style connectors, clearly marked Input + / Input – (for connection to the panel) and Output + / Output – (to adjacent Panel Monitor, for string connection).

6.2 Important Safety Considerations

- *Before wiring the Panel Monitor, confirm that the inverter is turned off; all AC and DC disconnects are set to the off position, and all string (combiner) fuses are open.*

For new arrays, once the Monitor is mounted to the frame rail, first connect input ports (panel side), and then output ports (string side). We suggest that strings be wired from "bottom to top" to minimize confusion and potential string wiring errors. Repeat this process until all monitors are mounted and wiring work is completed.

The inputs and outputs of the Monitors are clearly marked and the built-in MC4 connectors are specified clearly as positive or negative and keyed appropriately for direct connection to the PV panels and string neighbors using the industry standard MC4 polarity convention. However, if the site cabling has been prepared incorrectly, or if the labels on the Monitor enclosures are not adhered to, it may be possible to connect the Monitors incorrectly. These faults must be diagnosed and corrected as a part of the commissioning process, prior to inverter start.

- *Verify that all MC4 connectors are correctly mated and tight, loose connections may be difficult to troubleshoot and also may result in an arc-fault condition*

- *If the Monitor is connected with reverse polarity at its inputs or outputs, it will dissipate power and generate heat such that it becomes warm to the touch. There is protection circuitry within the module that is intended to protect it from permanent damage, however we recommend that such monitors be immediately disconnected.*

- *A Monitor installed "backwards" (i.e. input side wired to string and output side wired to panel) will dissipate power and generate heat such that it becomes warm to the touch. There is protection circuitry within the module that is intended to protect it from permanent damage, however we recommend that such monitors be immediately disconnected.*

- *Do not continue the string wiring process or attempt to start the inverter until all wiring faults as noted above are corrected. Monitors wired incorrectly will not report status to the Site Server.*

Any additional extension and/or adaptor cables necessary to interconnect panel or string wiring are the responsibility of the installer. Not all PV panels utilize the MC4 style connector. Typical adapter examples would include MC4 to MC3 or MC4 to Tyco adapter cables, email support@spowertech.com if you have questions regarding the design or use of such adaptor cables.

6.3 Site Documentation

If not already predefined, as part of the earlier Site Documentation Mapping process; the Identity and location of each Monitor and its related PV Panel should be documented during this install process.

Required information fields include:

- Monitor mac address/serial number
- Panel serial number (for warranty purposes)
- Panel location in array
- String name or number
- Position in String
- String to Combiner relationships, including combiner name and port number

Solar Power Technologies has standard templates available that simplify capturing data relationships for both the DC wiring topology, and the physical array layout. These can be found at www.spowertech.com.

Once this string documentation is completed, call our technical support line at *800-fix-mysolar*, or email the string documentation to *support@spowertech.com*: and our technical support team will load the information into your array commissioning interface.

Section 7 – Array Commissioning and Inverter Start

7.1 Verification of String Voltages

With Combiner Box fuses still open, use appropriate safety procedures to physically confirm all individual open circuit string voltages at each Combiner Box using a high-precision DC Voltmeter. There should be no more than a 2% difference between string voltage measurements. Note that correctly wired monitors are "transparent" with regards to string voltage: the open circuit voltages measured at the combiner box are identical as those observed on a string without monitors.

If significant differences in string voltage measurements are detected, check the string and panel wiring for fault conditions as described in Section 6.1. For example, a single loose MC4 input between a panel and monitor will result in a string voltage = Voc x (N-1) where Voc is the panel open circuit voltage, and N is string length.

Correct all string wiring faults identified and re-verify those string voltages at the combiner. Do not close string fuses, or attempt an inverter start if string voltage issues persist. If you problems resolving string voltages, call our technical support line at *800-fix-mysolar*, or email our technical support team at *support@spowertech.com*.

Once all strings have been verified log into your Intelligent Array account, and compare your measured string voltages with those reported on the string summary page, then note any obvious measurement differences.

Once all strings are verified, replace all removed combiner box fuses, and close any other open DC disconnects, such as switches or fuses in sub-combiners. As individual DC fuses and disconnects are closed, use the string summary page to observe impact to configured Monitor and String Voltage. Once all voltages look good, proceed to Section 7.2 – Inverter Start

7.2 Inverter Start

We recommend that the initial Inverter start be scheduled for early morning, low-sun conditions – this reduces any stresses to the Inverter or Array that might still exist due to wiring faults that have not yet been identified. Additionally, it allows for a full day of data collection and observation by the Intelligent Array Applications Suite.

Start the Inverter by closing its DC and AC disconnects; and after the inverter successfully completes its startup sequence, compare AC output power (as observed via the inverter's monitoring interface) with the Intelligent Array's String Power Summary Page. Total delivered DC String Power should correlate closely (within 5 to 6% in average irradiance) to the AC Power reported by the Inverter.

Next, log in and examine the Intelligent Array's String Power Comparison Page, and note any Strings with DC Power differing from the calculated String Average Power by more than 5%. Time of day variances of greater than 5% can be expected if some strings suffer hard shade (typically from adjacent structures during morning and late afternoon due to low sun angles).

Also note that moving cloud events may impact individual string output: these strings should recover quickly in clearing skies, and over time their output power should correlate to the calculated String Average Power.

After the several hours of operation, the Site Server will accumulate considerable performance data, which will prove useful in troubleshooting any chronically underperforming panels or strings.

Contact *support@spowertech.com* if you need additional troubleshooting support.

Section 8 – Troubleshooting Site Server and Gateway

Download the most recent version of this Installation Manual from:
http://www.spowertech.com/monitor/installandoperations.html

8.1 Site Server Troubleshooting

During initial commissioning, and on an ongoing basis, the Site Server must be powered up, and connected to the Internet. The Gateway must be correctly sited with regards to radio range and properly configured in order to identify and communicate with individual Monitors. Each Monitor must be correctly connected to its associated PV Panel, and exposed to irradiance, in order to power up its internal controller and related radio communications circuitry.

Log into your Intelligent Array account to confirm system status. The Intelligent Array application includes a System Status Page, which allows you to confirm the ID, status and functionality of individual Site Servers and Gateways installed in your Array. Additionally, this page provides information on radio mesh performance and operating mesh structure.

If the Site Server is not visible on the status page, the broadband connection to the Array may be compromised, or lost. If broadband Internet connectivity issues are suspected, connect a PC to one of the unused rBOX104 Ethernet ports in the Site Server using an Ethernet cable. Enable DCHP in network configuration, launch a browser, and connect to a remote website such as Google. If that remote network connection attempts fail, your network configuration may have been altered since the Site Server was installed. Contact your IT department and/or *support@spowertech.com* for network troubleshooting support.

8.2 Gateway Troubleshooting

If the Site Server is responding, but the Intelligent Array has not detected any Monitors, check the System Status Page to determine if all Gateways are operating correctly. Each gateway communicates with the Site Server on a regular basis, and any alarm condition generated is logged and reported on the System Status Page. Unresponsive Gateways are typically a result of wiring faults and/or mechanical damage.

If such damage is found, make necessary repairs and recheck the System Status Page. Gateways that are visibly damaged may be replaced in the field: such swaps are auto-detected by the Intelligent Array, and gateway functionality is restored without reprogramming or human intervention. If you are unable to clear Gateway-related system faults, contact support@spowertech.com for Gateway troubleshooting support.

8.3 Mesh Troubleshooting

If Gateways are functioning correctly, and the Intelligent Array does not detect Monitors; the issue may be mesh radio related. If radio range or interference issues are suspected, temporary relocate the Gateway to another area of the array: still keeping the gateway to within 5 to 10 feet of the nearest Monitor unit. Ensure that the

nearest Monitor is powered by its paired panel being exposed to direct irradiance, and recheck Monitor activity on the System Status page.

Lastly, configuration errors will also impact Gateway functionality. The site configuration file noted in Section 6.2 must accurately reflect the installed inventory of Monitors, and contain their correct mac address in order to enable mesh radio connectivity. The Gateway may not identify and communicate with correctly installed but undocumented units. Corrupted configuration files are another potential source of identification errors.

Note that correctly installed, but undocumented Monitors are transparent and will not impact power production, or on inverter operation.

Contact *support@spowertech.com* for additional mesh radio troubleshooting support.

Section 9 –Technical Specifications

		SPM80V12A		SPM125V8A	
		Standard	Switch Option	Standard	Switch Option
Input / Output Electrical Characteristics					
	Input DC Voltage (Voc max)	80 V		125 V	
	Input/String Current (Isc max)	12A		8 A	
	Measurement Accuracy (% error max)	0.5%		0.5%	
	Power Consumption (typ @ 50% Isc max)	288mW	504mW	144mW	288mW
Mechanical and Other					
	Dimensions	140mm x 88mm x 19mm			
	Weight	Approx 6 oz			
	Mechanical I/O	Integrated MC4 input and output			
	Temperature – Ambient	-30 °C to 70 °C			
	Cooling	Natural Convection (sealed)			
	Compliance	UL60950-1, CSA22.2# 60950-1, IEC 60950			
		FCC Part 15.247 & Class B, EN 300328/301489			
	Environmental Sealing	IP65			

- *Under extreme environmental conditions, a photovoltaic panel may produce higher short-circuit currents and/or higher open-circuit voltages than specified by the panel's nameplate Standard Test Condition (STC) rating. Accordingly, these higher values of Isc and Voc should be utilized when determining compatibility with the Monitor's maximum current and maximum voltage specifications.*

Section 9 – Limited Warranty (*Given to Legal for Input)*

Solar Power Technologies requires a Return Materials Authorization for all returned products. Contact Solar Power Technologies Customer Service at 512.782.8957, or email: support@spowertech.com.

Monitor PRODUCT WARRANTY

SP350V80 Limited Warranty (Manufacturing Workmanship and Materials)
Solar Power Technologies, Inc. warrants that its SPM80V12A, SPM80V12A-S, SPM128V8A, and SPM120V8A-S (the "Monitor(s)") will be free from defective workmanship and materials under normal application, installation, use and service conditions for a period of twenty (20) years from the date of purchase, the "Warranty Period." This Limited Warranty is provided to the solar system owner where Monitors installed initially or any subsequent owner of the system where the Monitors were first installed and remains installed, the "Owner".

During the Warranty period and provided Solar Power Technologies has verified the performance failure of Monitors, Solar Power Technologies agrees that it will, at Solar Power Technologies' option: (a) replace the defective Monitor with a new or remanufactured equivalent at no charge, (b) repair the defect with new and/or reconditioned parts at no charge, or (c) refund a "Prorated Amount" of the original "Purchase Price". For the purposes of this Limited Warranty, the Purchase Price shall be deemed to be the actual purchase price paid by the Owner as shown on the proof of purchase and in no event exceed the end-user (retail) Sales Price (RSP) set by Solar Power Technologies. The Prorated Amount shall be the percentage as calculated by the remaining full years of the Warranty Period divided by the total original Warranty Period.

Limitations and Conditions
Solar Power Technologies makes no warranty for performance, service or support of any products unless they are purchased through an authorized Solar Power Technologies Dealer or direct from Solar Power Technologies.

The Owner must properly register the Monitor units within 90 days of Owner purchase. The registration information required includes, purchase date, Monitor serial number/mac address, and original installation location.

Units not properly registered are subject to a manufacturing and materials Limited Warranty Period of one (1) year.

The Owner must provide proper notification to Solar Power Technologies. This notification must include Monitor serial number, proof of purchase, original installation location, the date defective unit was discovered, and a description of the defect found.

With the exception of the provisions listed above, this Limited Warranty does not cover any additional costs related to trouble-shooting, uninstalling the Monitor, reinstalling

the repaired or replacement Monitor, packaging & shipping or any other costs associated with obtaining warranty service hereunder. Monitors returned to Solar Power Technologies that are found to be in good working condition are subject to a restocking fee if the unit has not been in the field and subject to full replacement charge, including shipping charges, if it has been retired from the field and returned to Solar Power Technologies for Warranty replacement.

No claim under this Limited Warranty may be brought after the Warranty Period. Any repair or replacement of a Monitor shall not extend the original term of this Limited Warranty. In no event shall this Limited Warranty cover defects and/or failures of the Monitor which, in Solar Power Technologies' sole judgment, arise from any one or more of the following causes:

1. Improper or inadequate wiring and installation, including mounting to non-approved rack systems or hardware or connection to solar panels, panel strings or inverters that are not compliant with product specifications;
2. Use in a manner contrary to the Monitor operation and safety manuals or not in accordance with applicable laws and regulations;
3. Operation in an unsuitable environmental outside the specifications for the product;
4. Unauthorized maintenance, repairs or modifications including tampering with or altering the Monitor, either internally or externally;
5. Removal of Monitor from its original place of installation for reinstall at a different location;
6. Improper handling during transportation or storage;
7. Fire, water generalized corrosion, biological infestations, natural forces, acts of God, civil disorder, or other force majeure events, including high input voltage from generators or lightning strikes;
8. Smoke, salt damage, acid rain, or other pollutants;
9. Original identification markings (including trademark or serial number) of the Monitor having been defaced, altered, or removed.

UNDER NO CIRCUMSTANCES SHALL MONITORS BE USED FOR, OR IN CONNECTION WITH, THE GENERATION OF POWER FOR LIFE-SUPPORT DEVICES OR SYSTEMS.

THE LIMITED WARRANTY DESCRIBED HEREIN SHALL BE THE SOLE AND EXCLUSIVE WARRANTY GRANTED BY SOLAR POWER TECHNOLOGIES, WHERE PERMITTED BY LAW, AND SHALL BE THE SOLE AND EXCLUSIVE REMEDY AVAILABLE TO THE OWNER. SOLAR POWER TECHNOLOGIES MAKES NO OTHER WARRANTY, EXPRESS OR IMPLIED, INCLUDING WITHOUT LIMITATION ANY WARRANTY OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. SOLAR POWER TECHNOLOGIES SHALL HAVE NO RESPONSIBILITY OR LIABILITY WHATSOEVER FOR DAMAGE OR INJURY TO PERSONS OR PROPERTY ARISING OUT OF OR RELATED TO THE MONITOR. UNDER NO CIRCUMSTANCES SHALL SOLAR POWER TECHNOLOGIES BE

LIABLE FOR INCIDENTAL, CONSEQUENTIAL, OR SPECIAL DAMAGES HOWEVER CAUSED, EVEN IF SOLAR POWER TECHNOLOGIES HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. IN NO EVENT SHALL SOLAR POWER TECHNOLOGIES' LIABILITY BE GREATER THAN THE PURCHASE PRICE OF THE SP350V80 OPTIMIZER.

SOME JURISDICTIONS DO NOT ALLOW LIMITATIONS ON IMPLIED WARRANTIES OR THE EXCLUSION OF DAMAGES, SO THE OWNER MAY HAVE OTHER RIGHTS, WHICH VARY FROM JURISDICTION TO JURISDICTION. HOWEVER, ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS IS LIMITED TO THE DURATION PERIOD OF THIS LIMITED WARRANTY.