



Solar Power Systems

going **beyond** the ordinary

Installation, Operation and Maintenance Guide

12, 24, and 48 Volt Systems

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Ventev Innovations
(A Division of TESCO Technologies)
10999 McCormick Rd
Hunt Valley, MD 21031
Phone +1 (800) 759-9996

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The Solar Power System is designed to meet the limits pursuant to Part 15 of the FCC rules.

CE Compliance

The Solar Power Systems are designed to be CE compliant.



Safety Instructions

Retain all safety information for future reference. The following table defines precautionary safety terms used in this guide. Failure to observe these precautions when installing, using, or servicing this product violates this products intended purpose and may result in personal injury or damage to equipment.

DANGER	Indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.
WARNING	Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.
CAUTION	Indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury. It may also be used to alert against unsafe practices.
Listed	Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or services meets appropriate designated standards or has been tested and found suitable for a specified purpose.

Informational Note:

The means for identifying listed equipment may vary for each organization concerned with product evaluation, some of which do not recognize equipment as listed unless it is also labelled. Use of the system employed by the listing organization allows the authority having jurisdiction to identify a listed product.

Safety Symbols

Safety symbols shown on the Solar Power Systems must be observed when operating, servicing, or repairing the systems. Failure to comply with safety precautions shown on the Solar Power System components or in this guide violates the intended use of this product.

The following safety symbols appear on the Solar Power System components and in this guide:



GENERAL HAZARD

This symbol represents a general warning or caution

Read and Understand all Instructions

Always follow basic safety precautions when installing, using, or servicing this product to reduce the risk of fire, shock, and injury to person or damage to equipment. Basic safety precautions include, but are not limited to, the following:

- Review the drawings and illustrations in this manual before proceeding. If there are any questions regarding the safe installation or operation of the system, contact Ventev. Save this document for future reference.
- Use qualified service personnel to service equipment. Servicing is required when the equipment has been damaged and does not operate normally.
- Remove all conductive jewellery or personal equipment prior to beginning installation, servicing equipment, parts, connectors, wiring or batteries.
- Limit access to modules. Solar modules generate electricity when exposed to light. Arrays of many modules can cause lethal shock and burn hazards. Only authorized, trained personnel should have access to these modules.
- Cover modules with an opaque material during installation to reduce risk of electrical shock or burns.
- Use insulated tools for electrical connections and do not touch live terminals with bare hands.

Local Code and Permits

- Contact local authorities to determine and obtain the necessary permits before installing your solar system.
- Follow requirements of applicable local and national electrical codes.

Quick Start Guide

High-level steps to assemble, install, and commission of the Ventev Solar Power Systems include:

- 1 Select the optimal site.
- 2 Erect the pole mount.
- 3 Open the shipping packages and confirm all components and parts are on hand.
- 4 Mount solar modules and enclosure. Ground the system.
- 5 Assemble solar module interconnects (if applicable).
- 6 Ensure the tilt angle is optimized for the geographic location of the site.
- 7 Disengage fuses from fuse holders to interrupt DC circuits.
- 8 Connect solar module array to (+) and (-) terminal block.
- 9 Verify Solar Module array output polarity and voltage are correct.
- 10 Install battery(s) in enclosure and connect them to (+) then (-) terminal block.
- 11 Connect battery, then solar, then load fuse blocks.
- 12 Confirm operation by measuring voltages and monitoring solar controller lights.

About This Guide

Purpose and Scope

The purpose of this guide is to introduce the reader to the Ventev Solar Power Systems and to provide guidance in the successful installation and operation of these systems. This guide describes the enclosure components and functions, presents the operational theory and application of the systems, and provides task-based instructions for installing each of the Ventev Solar Power Systems and for operating the systems once installed.

Audience

This guide is intended for first time and experienced users. It is assumed that users have a basic understanding of electrical wiring techniques.

Organization

All standard Ventev Solar Power Systems are similar in architecture and configuration with variations in the configuration and number of batteries and solar modules deployed. The customer is advised to use the Door Wiring Diagram posted on the inside of the enclosure to match the purchased configuration against those illustrated herein then install and wire according to the instructions in this guide.

A roadmap to using this guide efficiently:

Refer to...	To...
Chapter 1, The Ventev Solar Power System Overview	Understand Ventev's Solar Power Systems, their theory of operation, architecture, and wiring. This section also provides a quick start guide to assembling the system.
Chapter 2, Solar Power System Installation	See step by step instructions to position, assemble, mount, and commission the Solar Power System and to service, maintain and operate the systems.
Chapter 3, Operation and Problem Resolution	Understand Ventev's Solar Power Systems operation and common problems and their resolution
Chapter 4, Maintenance	Understand recommended preventative maintenance techniques for the system solar modules, batteries, and electrical equipment housed in the enclosures.
Appendix A, Wiring Diagrams and Site Layout	See the different configurations of the various solar power systems provided by Ventev and a typical site layout.

Conventions

Following are typographical and icon conventions used throughout this guide.

Description	Example
A button or switch you press on a device appears in this TYPEFACE.	On the Enclosure, press the START button.
An arrow represents a note or a tip to convey related information.	

SAVE THESE INSTRUCTIONS

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Chapter 1 The Ventev Solar Power System Overview

This chapter presents an overview of the Ventev Solar Power Systems architecture and wiring configurations.

Experienced users of the Solar Power System will find this section provides a quick-start guide in assembling and maintaining the System while those new to the product will find detailed instructions for the installation, operation, and maintaining of the Systems.

Topics included in this section:

- **Quick Start Guide, page 4**
- **About Ventev's Solar Power System, page 10**
- **Theory of Operation, page 10**
- **System Description, page 11**
- **Wiring Diagram, page 16**

About Ventev's Solar Power System

The Ventev Solar Power Systems were developed to power equipment in remote locations where utility grid power is not available. Combinations of the solar modules, batteries, and solar controllers of the system enable flexible and scalable solutions to accommodate variations in geography, power level needs, and site specific applications.

Theory of Operation

Simply stated, batteries are used to power remote load needs with solar energy used to keep the batteries charged. However, the application of remote solar power systems presents a complex and varying set of challenges.

Solar modules, power controller modules, and batteries are the three primary components of the Solar Power System. Various combinations of the three allow the customer to choose a system that most matches site conditions such as load level requirements and availability of daily sunlight. With the deep cycle battery(s), recharged by solar modules, providing load power for customers' remote equipment, the power controller module optimizes control of battery recharging while protecting components during the extremes of solar energy availability as well as protecting the battery from damage due to overcharging. The controller module monitors local temperature and adjusts battery charging to minimize incorrect over or under charging.

Figure 1 illustrates a complete solar power system installation. The solar array is a group of solar modules that converts solar energy to electric power to keep the battery(s) charged. Depending on load needs, single or multiple solar modules create a solar array. The solar array supplies current through a solar controller to a bank of batteries to keep the batteries charged. Since the solar array is sized to power 100% of the load throughout the year, the solar modules are sized to match worst expected weather conditions (least amount of available sunlight) and mounted to maximize year round exposure.

The solar controller monitors battery terminal voltage and passes the current through from the solar modules to the battery bank to maintain charge on the batteries. As the battery voltage rises to 14.0 VDC, the controller limits the amount of current provided to the battery to prevent overcharging. As the terminal voltage drops, the controller will pass more current to the battery to maintain the terminal voltage. Since these systems are at sites with all weather conditions, the controller will also adjust this voltage for temperature compensation.

In situations where the battery voltage level could fall below 11.5VDC, such as continuous days of cloudy weather, the controller is designed to disconnect the load. When the battery charges to a voltage of 12.6VDC, the controller will reconnect the batteries to the load. This feature prevents discharging the battery to a level that could damage and shorten battery life.

System Description

Figure 1 illustrates a typical 12V Solar Power System installation that shows a high-level description of the system components.

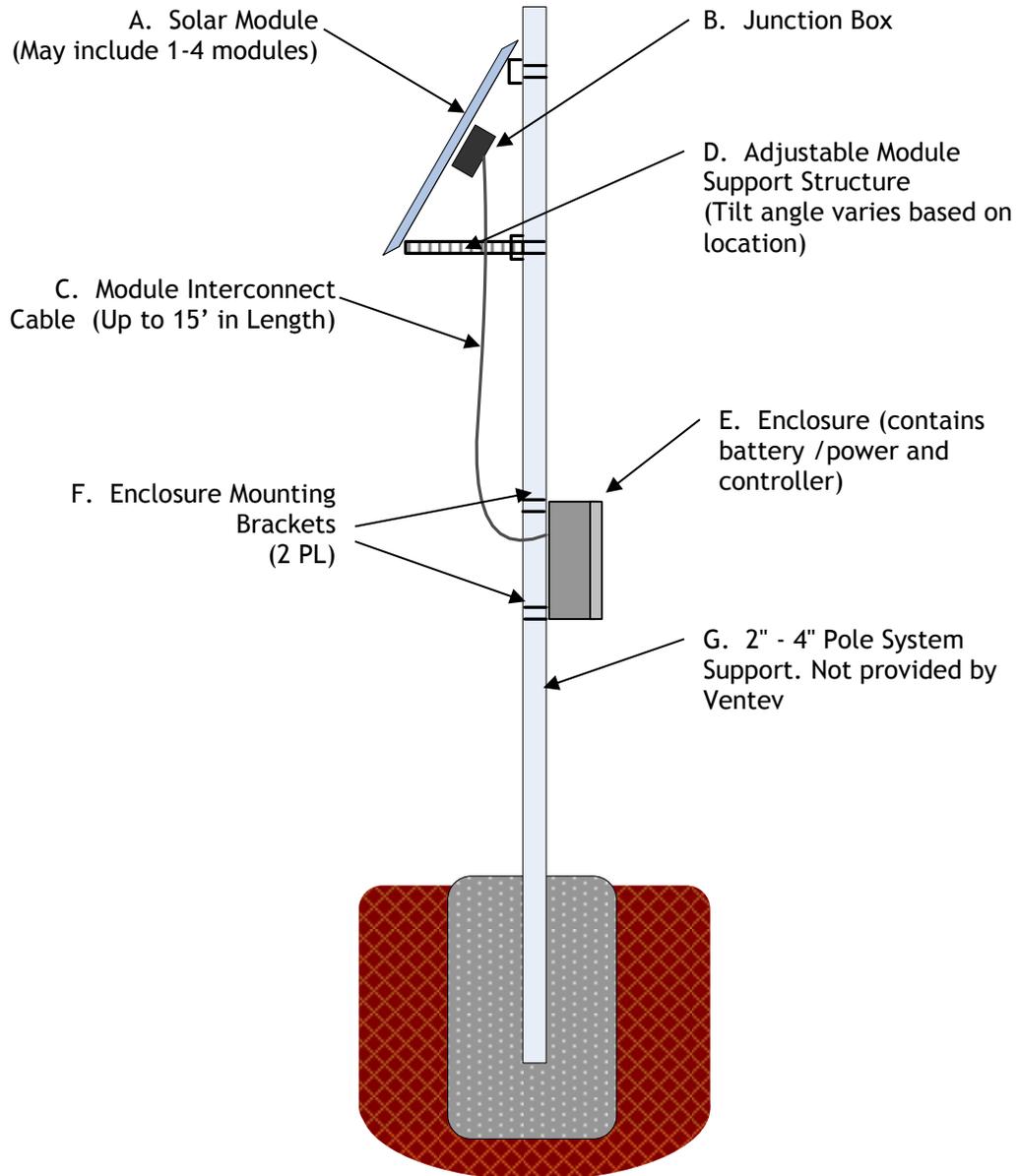


Figure 1: Solar System Architecture

The solar system is delivered to the customer site with each of the following major components.

A. Solar System Controller

The controller is the ‘heart and brains’ of the solar power system. It contains a 4 stage battery charging algorithm for rapid, efficient, and safe battery charging as shown in Figure 2.

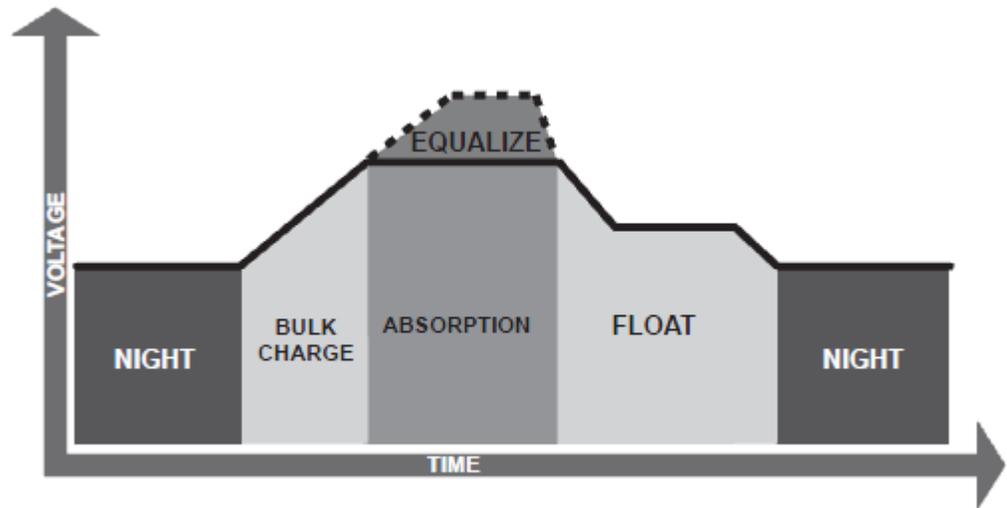


Figure 2: Battery Controller Charging Algorithm

In the bulk charge state, the battery voltage has not yet reached absorption voltage and 100% of available solar power is used to recharge the battery. Absorption voltage is the normal, fully charged state. When the battery has recharged to the absorption voltage setpoint, constant-voltage regulation is used to prevent heating and excessive battery gassing. After the battery has fully charged the controller reduces the battery voltage to a float charge (or trickle charge). Depending on battery history, the battery remains in the absorption stage for 3 or 4 hours before transitioning to the float stage.

Where flooded batteries are used, the controller will equalize the batteries for three hours every 28 days. Equalize charging raises the battery voltage above the standard absorption voltage so that the electrolyte gasses, preventing electrolyte stratification and equalizing the individual battery cell voltages. The controller also contains a special charging function to attempt to recover batteries that discharge too low.

The following protections are available and readily observable via LEDs on the controller faceplate:

1. Solar overload. If the solar current exceeds the maximum solar rating, the controller will stop charging until the solar current returns to within its operational rating. Status will be displayed on the faceplate via LEDs.
2. Load Overload. If the load current exceeds the maximum load current rating, the controller will disconnect the load. The controller will then attempt to reconnect the load two times approximately 10 seconds apart. If the overload

remains after these two attempts, operator intervention is required to clear the fault after normal current is verified. The fault condition will be displayed on faceplate LEDs until cleared.

3. Solar Module Reverse Polarity. The controller is fully protected against inadvertent reversal of lead connections. No damage to the controller will result, but the erroneous connection must be corrected for proper operation.
4. Battery Reverse Polarity. Similarly, the controller will not be damaged if battery leads are reversed, and again the problem must be resolved for proper operation.
5. Damaged Local Temperature Sensor. If the local temperature sensor is damaged, charging stops to avoid over- or under-charging. This critical error requires vendor support to resolve the failure.
6. Damaged Internal Temperature Sensor. Internal temperature of the controller is monitored on the controller heat sink. Temperatures above 85 Deg. C can damage internal controller electronics, so the unit shuts off when the heat sink exceeds that temperature. When the temperature falls below 80C, the controller resumes operation.
7. High Voltage Disconnect. If the battery voltage exceeds the controller's maximum regulation limit, the solar and load will be disconnected until the voltage decreases to the high voltage reconnect threshold. LEDs on the faceplate will display this status.

Load from the system is connected directly to the solar controller. The controller will disconnect loads when the battery has discharged to a low state of charge and reconnect system loads when battery capacity returns. Load control is fully automatic. As the battery discharges, status LEDs on the controller faceplate will show charge levels. The following general load control notes should be observed:

- 6, 10, and 20 Amp controllers provide load control.
- The controllers have a 15 V maximum voltage limit (30 V @ 24V).
- Load connection is NOT a regulated voltage output. Load terminal voltage is approximately the same as the battery voltage unless the controller is in load voltage condition where load is turned off.
- Currents of multiple loads wired in parallel must not exceed the total current rating of the controller.

B. Solar Module

Solar modules provide the energy source to keep battery(s) charged. The number of modules needed depends on site specifics, such as geographic location in the country, site specific needs such as load demand, and available/access to the sun. Figure 3 is a photograph of a typical solar module.

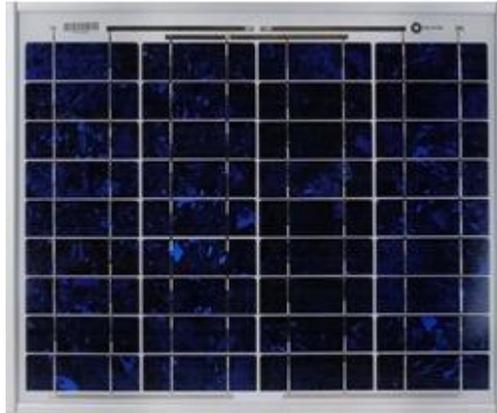


Figure 3: 12 Volt, 20 Watt Solar Module (BP Solar SX 3201)

Solar electric modules convert the sun's energy into direct current (DC) electricity. The systems contain a matrix of high performance monocrystalline or multicrystalline modules.

The Solar modules are securely attached to the pole with adjustable fasteners to enable tilt alignment to match the latitude at which the module is installed and horizontal adjustment for maximum tracking of the sun.

C. Junction Box

The junction box provides a junction to connect the module(s) to the solar controller through a fused circuit inside the enclosure. Multiple solar modules can be connected together, either in series or parallel depending on voltage requirements, and via a single multi-conductor cable connected to the solar controller.

D. Module Interconnect

The module Interconnect is a multi-conductor cable sized sufficiently to carry the current to the solar controller from the solar modules. The cable comes preconfigured with connectors, etc.

E. Adjustable Module Support Structure

The configuration shown in Figure 1 is a single solar module configuration. Support structures come in varying sizes and configurations to accommodate the types, number and size of solar modules and pole sizes on which they will be mounted. Therefore, the customer is required to provide the pole size consistent with the solar system size (which determines the pole size needed.)

F. Enclosure

The enclosure houses the battery, solar controller, wiring, termination blocks and fusing for the system. Figure 4 shows a typical enclosure in the configured system housing two batteries, wiring, and the solar controller.



Figure 4 Typical Enclosure with Solar Module

The enclosures arrive on site pre-wired per the purchaser's needs, including the solar controller, terminal blocks, and fuses mounted on DIN rails. The enclosure is typically sized to accommodate batteries which are staged in the bottom of the enclosure. Smaller system enclosures are of polycarbonate composition, and the remaining powder coated aluminium sized to accommodate the batteries required. Refer to TESSCO.com to review the current solar power enclosure sizes.

G. Enclosure Mounting Brackets

The enclosure mounting kits are used to attach the enclosure to the pole. The mounting brackets are sized to match the system, and kits provided to fit 2 3/8" and 4 1/2" OD pipes.

H. Pole System Support

The mounting poles are not part of the solar system package, but can be provided separately. Sizing will depend on the solar system purchased, including number of modules needed, enclosure size, etc.

Wiring Diagram

Figure 5 is a copy of the door wiring diagram for the 12 Volt, 10 Watt solar system.

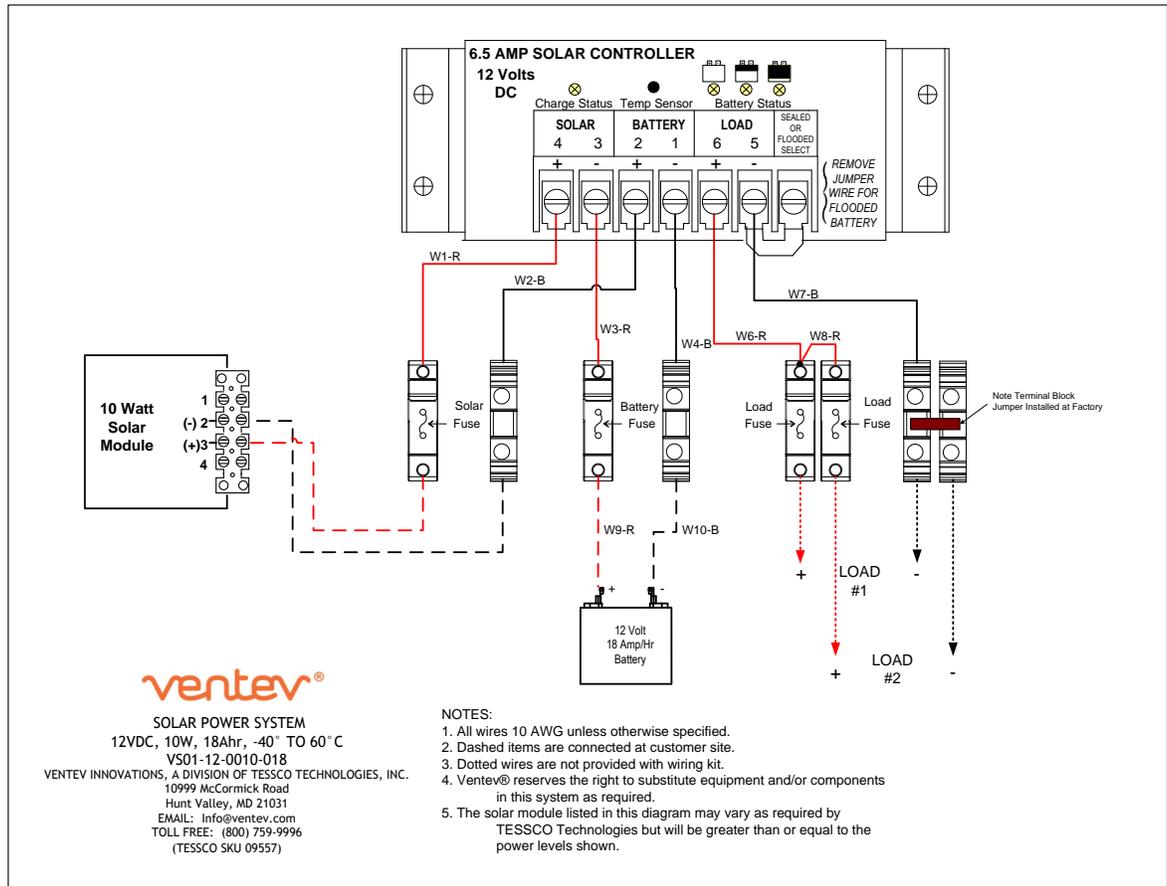


Figure 5: 12 Volt, 10 Watt Solar System Wiring Diagram

With the enclosure delivered to the site pre-wired, solid lines in the diagram (Figure 5) indicate factory wiring, dashed lines represent wiring provided with the system but require on-site installation and connection after the solar modules are mounted and battery(s) installed. Dotted lines indicate wiring not provided in the package that are to be supplied on-site by the customer.

Chapter 2 Solar Power System Installation

This chapter provides detailed instructions to install the 12V Solar Power System for operation. Topics discussed in this chapter include the following:

- **Installation Overview, 18**
- **Identifying a Site, page 19**
- **Assembling and Mounting Guidelines, page 24**
- **Mounting the Battery Enclosure**
- **System Wiring, page 25**
- **Wiring and Installing the Battery, page 31**
- **System Checkout and Commissioning 32**

Installation Overview

This section describes the installation of a basic system.

Required Tools

The following tools will be needed to assemble the Solar Power System:

- Screw driver
- Socket and wrench set
- Small Hammer
- Pliers
- Voltage meter
- Compass

Before You Begin

The system must be installed as described in this manual to ensure reliable operation of the systems.

Confirm system load is consistent with design specifications and your established Ahrs/day load will not exceed the battery capacity in the targeted days of autonomy required.

Figure 6 is a copy of Ventev Solar Sizing Map from the Ventev website.

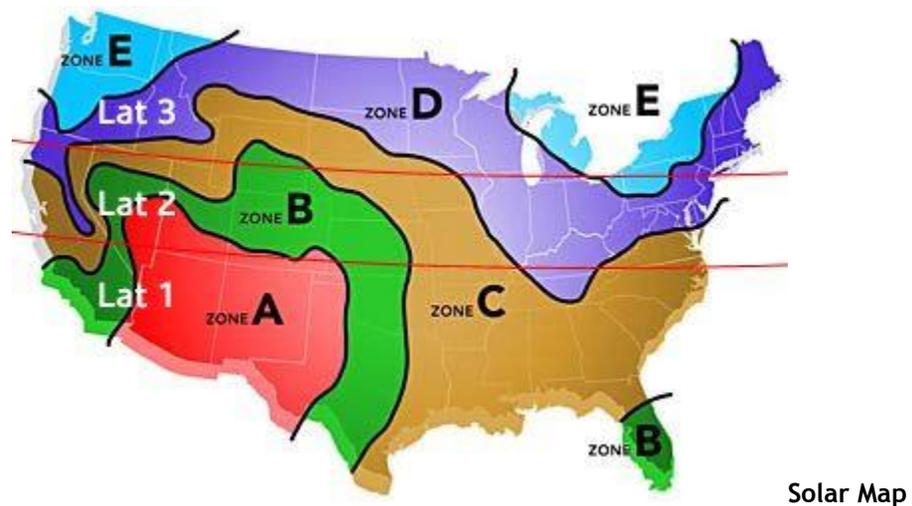


Figure 6: Ventev Solar System Sizing Map from the TESSCO Website



Note: Moving a Ventev Solar Power System from the original design site can be detrimental. For example, systems designed for installation in Zone A (Fig. 5) will not work in Zone E, so it is critical to size the systems according to the guidelines on Tessco.com. If you have any questions about matching your system requirements to the Ventev solar map, contact Tessco Customer support at (800) 472-7373. To maintain warranties the system location and load(s) must stay within site specifications for which it was intended.

Identifying a Site

Careful selection of the exact location for placement of the system is crucial to continuous and reliable system operation. Exposure to shadowing from cut hillsides, trees, utility poles or any other objects during sunlight hours will reduce power capacity and should be avoided.

To Select a Site

Shading critically affects a photovoltaic array's performance. Even a small amount of shade on a PV module can reduce the module's performance significantly. It is essential to have a clear understanding of the sun's path across the horizon from the east to the west.

Unfortunately it is not possible or practical to monitor the sun exposure at a site through long-term observation. Solar contractor installation professionals have developed tools to provide quick insight to the solar window at a specific location. In principle these tools evaluate a site by creating a Sun Chart. If a site is partially shaded, the sun chart will determine the amount of available sunlight.

The sun chart will determine if the solar modules will be shaded from direct beam radiation during critical times of the day or year. Unwanted shading can occur from trees, vegetation, structures, other arrays, poles, and wires. Shading is often a greater problem during winter months when the sun's altitude is low and shadows are longer. For locations in the northern hemisphere, shadows cast on December 21st are the worst case through-out the entire year.

When a site is being considered, be sure that the following parameters are considered:

- Assure the array is not shaded from 9 a.m. to 3 p.m. on any day (this is the optimum solar radiation collection time known as the solar window).
- Assure the array is not shaded in any month of the year during the solar window.
- Identify the obstacles that shade the array during the solar window.
- Eliminate any shading, or move the array to avoid shading, or contact TESCO Technologies to increase the size of the array to offset losses due to shading at the site location.
 - Keeping the above factors in mind when installing the Ventev Solar Power Systems will help ensure optimal, reliable performance of your system based on the original, specified design parameters.

Helpful websites that are available:

<http://www.magnetic-declination.com/>

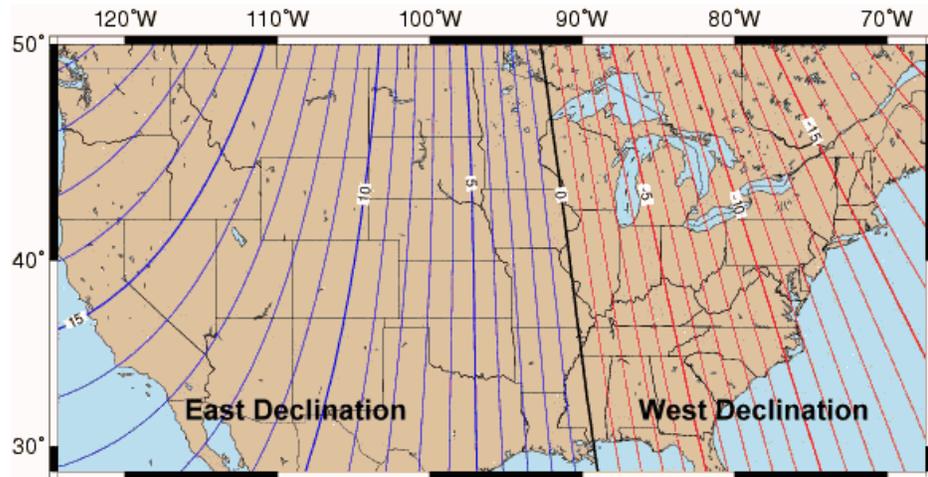
<http://www.ngdc.noaa.gov/geomagmodels/Declination.jsp>

If using a compass, be sure to adjust for the magnetic declination in your area (for example, around Hunt Valley, MD, true south is 11 degrees west of magnetic south).



Note: Magnetic declination changes over time and with location.

The map in following figure shows the current magnetic declination in the U.S. in December 2010.



Source: Compassdude.com

Figure 7: Map Showing Magnetic Declination for the U.S. in 2010



Note: An initial Site Survey is required to determine optimal tilt angle of the module for instance of worse case solar radiation (i.e. worst case in the Northern Hemisphere likely in December, so tilt angle should be latitude plus 15Deg). Record and retain as Initial Site Module Orientation Data.

Determining the Solar Module Tilt Angle

The sun's height above the horizon is called altitude, which is measured in degrees above the horizon. When the sun appears to be just rising or just setting, its altitude is 0 degrees. When the sun is true south in the sky at 0 degrees azimuth, it will be at its highest altitude for that day. This time is called solar noon.

A location's latitude determines how high the sun appears above the horizon at solar noon throughout the year. As a result of the earth's orbit around the sun with a tilted axis, the sun is at different altitudes above the horizon at solar noon throughout the year.

Photovoltaic module(s) or arrays work best when the sun's rays shine perpendicular (90 degrees) to the cells. When the cells are facing the sun in both azimuth and altitude, the angle of incidence is "normal", as shown in Figure 8.

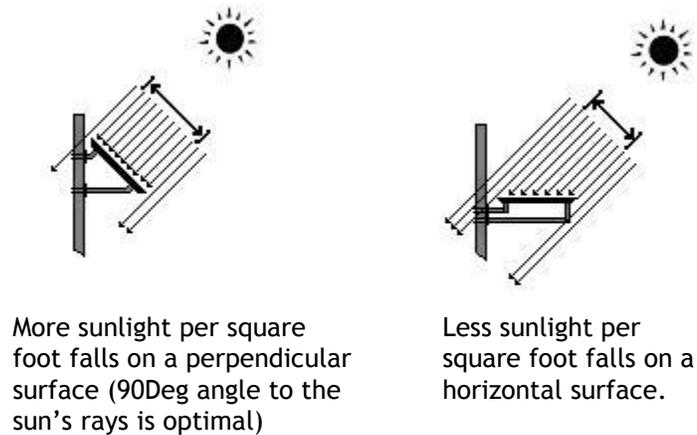


Figure 8: Angle of Incidence on a Solar Module

Seasonal changes of the sun's altitude must be considered to optimize a system's performance. When the array is installed, it should be tilted at an angle that yields the highest value of insolation during the worst case month in the year. This ensures that the system is designed to meet the load demand and keep the battery fully charged in the worst month for the average year. The following general guidelines outline a rule of thumb tilt angle of a solar module for different seasonal loads.

Winter loads Northern Hemisphere: Tilt angle = site latitude + 15°

Winter loads Southern Hemisphere: Tilt angle = site latitude - 15

The best method to determine the optimal tilt angle is to perform a site survey; contact TESCO Technologies for assistance with these professional services.

Assembling and Mounting the Solar Module Support Structure

The load capacity, equipment size and geographic location of the Solar Power System purchased determines the number of solar modules needed. Also, mounting configurations are driven by the pole size and number of solar modules needed. The following figures show various pole mounting configurations for the solar modules and how the module interconnect conduit assembly is installed in a 2-solar module mount assembly.



Figure 9: Pole Mounted Module

Figure 9 shows how the interconnect conduit assembly is installed on a two module assembly.



Figure 10: Dual Arm Single Module Mount



Interconnect conduit assembly in a 2-panel mount assembly

Figure 11: Two Module Mount with Module Interconnect Conduit Assembly



Figure 12: Single Arm Single Module Mount

Refer to the Solar Electric System in the Assembly Drawing (included with the support structure) for assembly details. Observe the following important guidelines when assembling and mounting the solar modules.



CAUTION: Avoid rough handling of the solar module. The module glass is tempered and may shatter upon impact. Solar modules are active when exposed to sunlight. To prevent power output at electrical terminals lay the solar module(s) face down on a flat, protective surface, or cover the front surface of the module with sunlight resistant material during assembly. Also, avoid shorting the terminals whenever sunlight is present on the module front surface.

Assembling and Mounting Guidelines

Figure 13 illustrates the proper orientation and wiring configuration for connecting the junction boxes of multiple modules.

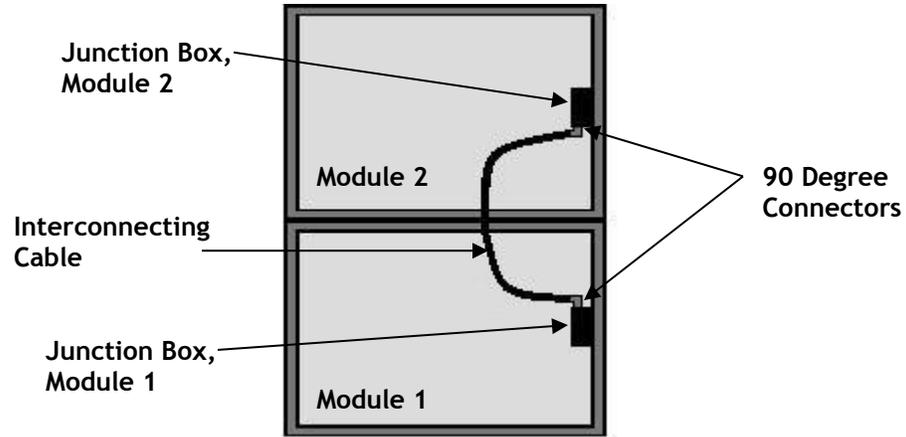


Figure 13: Module Junction Box Connection

Be certain to position the modules such that the junction boxes are on the same side in the series. For easiest access, use the junction box penetration hole toward the center of the module for attaching the 90 degree connectors. Instructions for connecting multiple modules follow.

- 1 Lay the modules face down on a flat, protected surface when attaching the support rails to prevent damaging the glass and to eliminate electrical hazard.
- 2 Take great care in the use of hand tools in the vicinity of modules' back surface. The module back surface materials are easily punctured, and any opening in the back surface will allow the entry of moisture which can shorten module service life. If punctures occur, seal with a non-acidic, commercial grade RTV sealant.
- 3 Remove the junction box hole tab closest to the middle of the module.
- 4 Attach the 90 degree connectors as shown in Figure 13.
- 5 Connect wiring to the terminals in the configuration shown in Door Wiring Diagram for the system delivered.
- 6 Look for specific manufacturer's instructions in the packaging, and if found, follow them carefully.

Mounting the Battery Enclosure

The physical size and weight of the batteries varies depending on storage capacity dictated by design requirements. The batteries are housed in the bottom of the enclosure which is attached to the pole.

Mounting Enclosure to Pole

- 1 Take the two clamps/U-bolts from the hardware bag for the appropriate pole size, hex nuts, bolts and washers.

- 2 Position the battery box against the pole and install the clamps/U-bolts loosely using hardware described above.
- 3 Position the enclosure against the north side of the pole (opposite the array, to take advantage of any shading available for reduced heat on the battery(s) and electronics in the enclosure) and tighten the bolts (Check for level before tightening), with the conduit knockouts on the bottom.



TIP:

To achieve optimal battery performance, position battery enclosure such that it will see optimal shade during summer months.

System Wiring



CAUTION:

Remove all fuses and turn OFF all circuit breakers before beginning any wiring.

Grounding

Equipment grounding is required, this is true even in low-voltage (12 and 24 Volt) systems. A grounding electrode must be added to an ungrounded system to accommodate the equipment grounds. Equipment grounding conductors and devices need to fall within the guidelines of the following, these guidelines are superseded only by more up to date requirements, or those outside of the 50 United States and its territories. The highlights below are paraphrased from the provisions that have been established through 2011 edition of the NFPA 70®, National Electric Code® of the United States of America; more detailed guidelines can be determined by referencing the entire code book itself.

- 1 **Equipment Grounding Required.** Exposed non-current carrying metal parts of PV module frames, electrical equipment, and conductor enclosures shall be grounded in accordance with
 - a. **250.134 Types of Equipment Grounding Conductors.** Includes:
 - i. A copper, aluminium, or copper-clad aluminium conductor, stranded or aluminium; insulated, covered, or bare; and in the form of a wire or a busbar of any shape
 - ii. Rigid metal conduit
 - iii. Intermediate metal conduit
 - iv. Electrical metal tubing
 - v. Listed flexible metal conduit
 - vi. Listed liquidtight flexible metal
 - vii. Flexible metallic tubing where the tubing is terminated in listed fittings
 - viii. Armor of Type AC cable.
 - ix. The copper sheath of mineral-insulated, metal-sheathed cable.

- x. Type MC cable that provides an effective ground-fault current path.
- xi. Cable trays.
- xii. Cablebus framework.
- xiii. Other listed electrically continuous metal raceways and listed auxiliary gutters.
- xiv. Surface metal raceways listed for grounding.

b. 250.136(A) Equipment Secured to Grounded Metal Supports.

- i. Electrical equipment secured to and in electrical contact with a metal rack or structure provided for its support and connected to an equipment grounding conductor.
- ii. The structural metal frame of a building shall not be used as the required equipment grounding conductor for AC equipment.

2 Equipment Grounding Conductor Required. An equipment grounding conductor between a PV array and other equipment shall be required in accordance with 250.110.

3 Structure as Equipment Grounding Conductor. Devices listed for grounding the metallic frames of PV modules or other equipment shall be permitted to bond the exposed metal surfaces or other equipment to mounting structures. Metallic mounting structures, other than building steel, used for grounding purposes shall be identified as equipment-grounding conductors or shall have identified bonding jumpers or devices connected between the separate metallic sections and shall be bonded to the grounding system.

4 Photovoltaic Mounting Systems and Devices. Devices and systems used for mounting PV modules that are also used to provide grounding for the module frames shall be identified for the purpose of grounding PV modules.

5 Adjacent Modules. Devices identified and listed for bonding the metallic frames of PV modules shall be permitted to bond the exposed metallic frames of PV modules to the metallic frames of adjacent PV modules.

6 All Conductors Together. Equipment grounding conductors for the PV array and structure (where installed) shall be contained within the same raceway or cable or otherwise run with the PV array circuit conductors when those circuit conductors leave the vicinity of the PV array.

Load Wiring

- 1 Locate the wiring diagram on the door.
- 2 Wire the load equipment to the Solar Controller terminal blocks according to the wiring diagram, carefully observing correct polarity.

Array Wiring

The customer load requirements, geographic location of the system, and available sunlight are among the factors that dictate the number of modules provided with the system and determines the circuit wiring configuration specific to the site needs. The Solar Module module has a junction box located on the back side of the module. The junction box is designed to accommodate standard wiring and/or conduit connections. All wiring and electrical connections should comply with the

National Electrical Code (NEC), Article 690 Solar Photovoltaic (PV) Systems. A cable clamp with a minimum rating of IP65 must be used to maintain the weatherproof integrity of the junction box. Bypass diodes are preinstalled at the factory.

The following figures illustrate the various module wiring configurations of the Solar Power Systems. To determine the module wiring configuration for your system, locate the wiring diagram on the door of the enclosure for your system and compare the module wiring to your system.

Single Module Solar Module Wiring



CAUTION:

Remove all fuses and turn OFF all circuit breakers before beginning any wiring.

Keep solar modules face down on a flat surface and/or cover the module(s) face with a sun protective cover while wiring.

Shorting solar module terminals together can damage the modules, so use care in handling connected wiring.

Figure 14 illustrates the terminal connections on a single solar module.

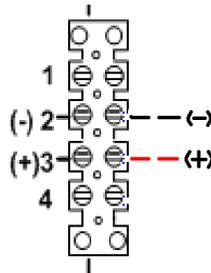


Figure 14: Single Module Terminal Wiring

The process for wiring a single module panel terminal block:

1. Open the solar module junction box by loosening the screws.
2. Connect #10 AWG black wire from the solar module terminal two (2) to the terminal block that connects to the Solar Controller Terminal three (3).
3. Connect #10 AWG red wire from solar module terminal 3 to the fuse block that connects to Solar Controller Terminal four (4).

Multiple Modules Connected in Series

Figure 15 shows the wiring configuration for multiple modules connected in series. This configuration allows solar modules to be grouped to match voltage levels required in the system design (two 12 Volt modules wired in series converts to a 24 Volt system). Note and carefully observe polarity while connecting the modules.

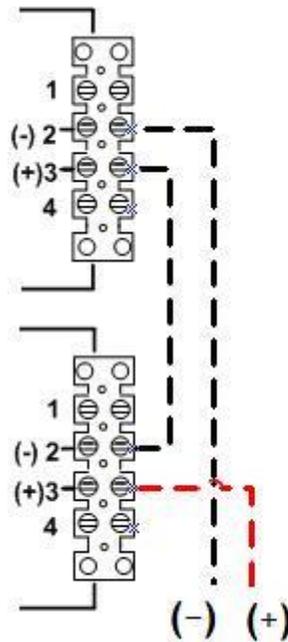


Figure 15: Multiple Solar Modules Connected in Series

Carefully observe and note polarity when wiring the modules. Steps for wiring modules in series as shown in Figure 15 include:

1. Open the solar module junction boxes on all modules by loosening the screws.
2. Connect #10 AWG black wire from terminal two (2) (negative) on the first solar module in the series to the Solar Controller Terminal three (3) (negative).
3. Connect #10 AWG red wire from terminal three (3) (positive) on the last solar module in the series to the terminal block that connects to the Solar Controller Terminal four (4) (positive).
4. Connect a #10 AWG black wire from terminal two (2) (negative) on the first module in the series to terminal three (3) (positive) of the second module in the series.
5. Repeat step three until all modules have been wired together.
6. Connect #10 AWG red wire from the last module in the series terminal 3 to the fuse block that connects to Solar Controller Terminal four (4).

Multiple Modules Wired in Parallel

Multiple modules wired in parallel as illustrated in Figure 16 enables power wattage to be incrementally increased while retaining the voltage levels of each individual module (i.e. If the modules in the figure are 12 volts each, then 12 volts are presented to the Solar Controller with the power capacity of all three combined).

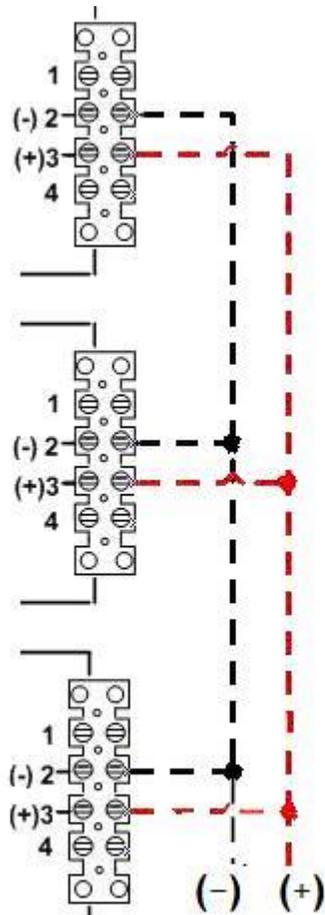


Figure 16: Multiple Solar Modules Connected in Parallel

Figure 17 illustrates the junction box used in wiring multiple modules in parallel.

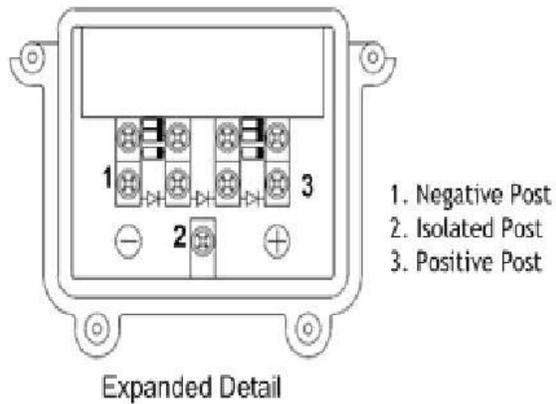


Figure 17: Solar Module Junction Box

The steps involved in wiring multiple modules in parallel include:

- 1** Remove the strain relief locknut from the conduit end marked "ARRAY". Insert the end into the junction box, replace the locknut and tighten.
- 2** Terminate the 30" interconnect cable as shown in Figure 13.
- 3** Terminate the wire ends as shown in the Door Wiring Diagram and Figure 15 (Red +, Black -). Tighten the terminal screws to no more than 21 in-lbs. Check your connections to make sure they are the correct polarity. Close and secure the cover.
- 4** Locate the hole in the back or bottom of the battery enclosure.
- 5** Remove the strain relief locknut from the conduit end. Insert the conduit end into the battery enclosure, replace the locknut, and tighten.
- 6** Connect the array wires to the terminals marked "Array +" and "Array -" (Red positive, Black negative).

Wiring and Installing the Battery

Battery(s) are shipped separately and not installed in the enclosure before shipment.

Observe the following guidelines when working with batteries.



CAUTION: Electrical Burn Hazard

A short-circuited battery can produce thousands of amperes that will melt hand tools and cause severe burns. Take great care when handling the batteries and installing their interconnection wiring.



CAUTION:

Wear eye protection and gloves. Remove all metal that can come in contact with battery terminals.



TIP:

Keep the array, batteries, and loads as close together as possible. Due to electrical resistance of the interconnect wires, the electrical output drops over long distances. Shorter distances between the components of the PV power system minimize voltage drop and will also reduce wiring costs.



CAUTION:

Use extreme care in placing the battery(s) into the enclosure, being careful not to short battery terminals to the enclosure casing.



NOTE:

Consult the wiring diagram on the enclosure door of the delivered system to determine the configuration of the battery(s) supplied. Locate that configuration in this section then follow the installation instructions herein for your system.

To accommodate varying load requirements, the Ventev Solar Power Systems come equipped with the number of batteries and various battery amp-hour capacities required to meet design. The number of batteries depends on the required load and geographic location where the system will be installed. 12 Volt and 24 Volt solar power systems are provided and since all batteries used are 12 volts, the batteries are often connected in series to yield 24 volt capacity. With amp-hour capacities designed to fit load demand, geographic location, and available sunlight, the battery capacity and physical size varies from system to system.

Single Battery Connection

Figure 18 illustrates a single battery configuration.

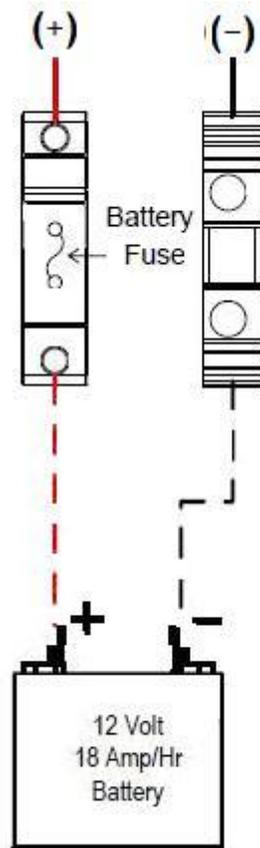


Figure 18: Single Battery Connection

The dashed lines indicate wiring that must be connected on site after the batteries are positioned and anchored.

To Install and Wire a Single 12 Volt Battery

- 1 Remove the appropriate punch-outs from the battery label to indicate the month and year of installation (6 = 2008). This step is very important for tracking battery performance and warranty information.
- 2 Set the battery into the enclosure.
- 3 Connect the RED lead(s) to the POSITIVE (+) terminal of the battery using the bolts, washers, and nuts provided. Tighten battery connections to 100 in-lbs. Take care not to short circuit the battery terminals with the wrench to the negative terminal or to the enclosure casing.
- 4 Connect the BLACK lead(s) to the NEGATIVE (-) terminal of the battery in the same way, observing the same precautions.
- 5 Make sure that the battery terminals are completely covered by the insulating boots.

Multiple 12 Volt Batteries in Parallel

Connecting 12 Volt batteries in parallel enables incremental increase in amp-hour capacity. For example, two 40Amp-Hour batteries connected in parallel increases total capacity to 80Amp-Hours. Figure 19 shows the wiring configuration for parallel battery connection.

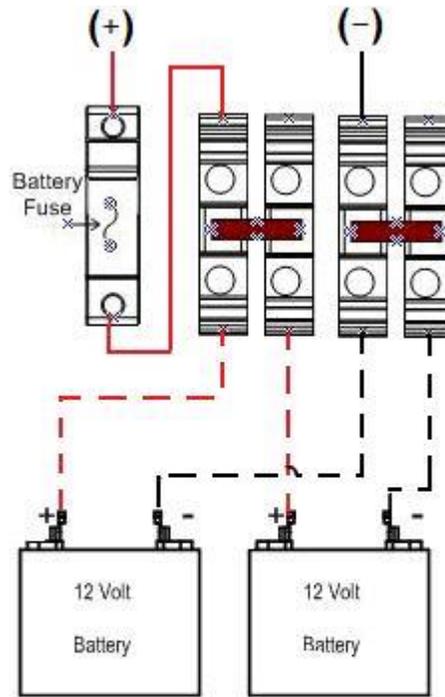


Figure 19: Parallel 12 Volt Battery Configuration

The dashed lines indicate wiring that must be connected on site after the batteries are positioned and anchored.

To Install and Wire Multiple Batteries in Parallel

1. Remove the appropriate punch-outs from the battery labels to indicate the month and year of installation (6=2008). This step is very important for tracking battery performance and warranty information.
2. Set the batteries into the enclosure.
3. Connect the RED leads to the POSITIVE (+) terminals of each battery using the bolts, washers and nuts provided. Tighten battery connections to 100 in-lbs. Take care not to short circuit the battery terminals with the wrench to the negative terminal or to the enclosure casing.
4. Connect the BLACK leads to the NEGATIVE (-) terminal of the batteries in the same manner, observing the same precautions.
5. Make sure the battery terminals are completely covered by the insulating hoods.

Multiple Batteries Connected in Series

Connecting multiple batteries in series increases the overall voltage by the number of batteries multiplied by the voltage of each. Given the two batteries in Figure 20 are 12 volts, the resulting voltage is 24 volts.

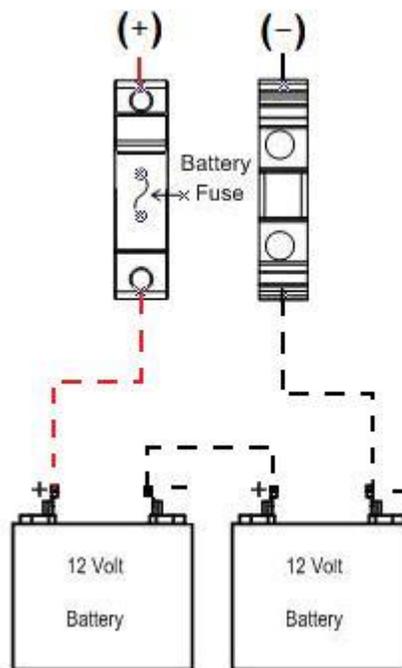


Figure 20: Multiple Batteries in Series

The dashed lines indicate wiring that must be connected on site after the batteries are positioned and anchored.

To Install and Wire Multiple Batteries in Series

1. Remove the appropriate punch-outs from the battery labels to indicate the month and year of installation (6 = 2008). This step is very important for tracking battery performance and warranty information.
2. Set the batteries into the enclosure.
3. Select one of the batteries as Battery No. 1. Connect the RED lead to the POSITIVE (+) terminal of Battery No. 1 using the bolts, washers and nuts provided. Tighten battery connections to 100 in-lbs. Take care not to short circuit the battery terminals with the wrench to the negative terminal or to the enclosure casing.
4. Connect one end of the short black 10 AWG jumper wire to the NEGATIVE (-) terminal of Battery No. 1 and the other end to the POSITIVE (+) terminal of Battery No. 2. Again, be careful not to short circuit the battery terminals to each other or short them to the enclosure casing.
5. Connect the BLACK lead to the NEGATIVE (-) terminal of Battery No. 2 in the same way, observing the same precautions.
6. Make sure that the battery terminals are completely covered by the insulating boots.

System Checkout and Commissioning



DANGER:

Closing the fuse holder to energize the system may create sparks. Never energize the system in the presence of explosive vapours. Close all fuse holders to energize circuitry.

After the mechanical and electrical installation is complete, check the integrity of all electrical terminations and mechanical fasteners. Perform the electrical checkout described below.

1. Select the optimal site.
2. Erect the pole mount.
3. Open the shipping packages and confirm all components and parts are on hand.
4. Mount solar modules and enclosure. Ground the system.
5. Assemble solar module interconnects (if applicable). Test the polarity and voltage produced by the array. On a clear sunny day, the readings should be above the battery voltage listed specifications for the system.
6. Ensure the tilt angle is optimized for the geographic location of the site.
7. Ensure that the controller has been set for the correct battery type.
8. Disengage fuses from fuse holders to interrupt DC circuits.
9. Connect solar module array to (+) and (-) terminal block.
10. Install battery(s) in enclosure and connect them to (+) then (-) terminal block.

- 11** Close the battery, then solar fuse blocks.
- 12** Confirm operation by measuring voltages and monitoring solar controller lights.
- 13** Verify the "CHARGING" light on the Solar Controller is ON. If it is not ON, recheck all connections for tightness. Turn on the load and verify its proper operation.
- 14** Close the load terminal block. Perform a series current draw reading while the load is operating and confirm that they are within the design limits of the system.
- 15** The solar power system is now fully functional.
- 16** Close the enclosure door and secure the system.

Chapter 3 Operation and Problem Resolution

This section describes the 12V Solar Power System operations. Topics discussed in this chapter include the following:

- **System Operation, page 35**
- **System Verification and Problem Resolution, page 376**
- **Technical Support, Page 36**

System Operation

The Ventev Solar Power Systems enable users to place power centers in remote locations where utility electric service is unavailable to power equipment such as remote radio transmitters, remote railroad switching, etc. The simple principle of operation lends itself to reliable service because the systems are carefully designed to meet specific customer needs at unique and specific site locations.

Principle of Operation

Banks of batteries (ranging from a single battery to an extensive bank of multiple batteries) power the load required by the customer. Battery charge is maintained via an array of solar collectors attached to or in the vicinity of the battery bank.

Elements of the System

1. Solar Array System
2. Enclosure that houses:
 - a. Solar Controller
 - b. Battery(s) (when the number and size permits. Otherwise the batteries are housed in a separate battery bank enclosure.)
 - c. Wiring, terminal blocks, and fusing
3. Battery Bank

While the battery bank and solar array provide continuous power to the customer load, the Solar Controller is the 'heart' of the system. The controller passes power from the solar collectors to the battery, monitoring voltage levels both from the collector and of the batteries to protect equipment. The solar controllers monitor battery voltage and limits current flow when the batteries are at or near full charge. The controller also protects the batteries from damage due to excessive discharge by removing the load when or if the batteries reach a level at which further discharge could be damaging.

As mentioned earlier, Ventev Solar Power Systems are sized depending on geographic siting location, customer power needs, and available sun energy. Great care is taken to factor these issues into the design of the systems, but each issue is a variable in itself that can and does affect the system operation. For example, a longer than expected string of days with clouds and/or rain can restrict available energy for charging the batteries. Also, there may be periods of increased unexpected load requirements, which affect the capacity of the charging system to 'keep up' with the load. For these reasons one should keep in mind there are always unforeseen conditions that can impact the systems operation.

System Verification and Problem Resolution

System performance below design expectations usually results in one or more of the following:

1. A load exceeding initial design estimates. If the load is operated on a daily basis for more hours than specified in the original system design, load failure may result.
2. Excessive load current draw. If the applied load draws more current than specified in the system design, load-operating time may be reduced or load down time may be experienced.
3. System component damage or malfunction may be a result of one of the following reasons:
 - A physically damaged solar module will produce less or no power (depending on the severity of the damage).
 - The solar controller may experience malfunction due to excessive current, for example, a lightning strike.
 - Excessive load operation may result in permanent battery damage for example, excessive deep discharge.
 - Loose or damaged wiring can cause severe voltage drop (power loss) or an open circuit of the array, battery, or load.
 - The solar power system site must be inspected regularly for damage. Damage may be a result of vandalism, wildlife, or lightning strike. The inspection frequency is site specific, depending on wildlife and/or public personnel activity in the vicinity.
4. System autonomy is the consecutive number of days that the battery subsystem is required to meet the load demand with no energy production from the solar module (or solar array), Poor sunlight conditions, such as ice/snow build-up on the solar module (or solar array), for consecutive days beyond autonomy design expectations, will result in non-operation of the load.

5. Shading of the solar modules during any period of the day will result in reduced system energy output. Shading can result from improper installation of the solar modules near trees, hillsides, or utility poles. Shading can also result from excessive dirt or bird droppings on the solar modules. The solar modules must be inspected and cleaned at regular intervals suitable to the conditions of the specific installation site.
6. Incorrect orientation or tilt angle of the solar modules will result in reduced energy conversion and reduced load operating time. If the array mounting hardware becomes loosened, high winds may alter its orientation. Always check the mounting fasteners for tightness and module orientation for proper directional orientation during site visits.

Technical Support

If you are unable to resolve issues after referring to this manual, please contact technical support for additional help:

Ventev Innovations (A division of TESSCO Technologies)

10999 McCormick Rd

Hunt Valley, MD 21031

Phone +1 410.858.0537

Chapter 4 Maintenance

This chapter describes how to maintain the 12V Solar Power System. Topics discussed include the following:

- **Solar Array, page 40**
- **Battery Bank and Charge Controller, page 40**
- **System Wiring, page 42**

Solar Array

The solar array converts sun energy to DC current at the design voltage (12 and 24 Volts in the Ventev Systems). Optimal operational efficiency requires the modules be kept clean and free of dust and debris and have full sun access dawn to dusk. The modules are mounted in fixed positions and should be orientated to face due South with tilting of the modules matching the average sun elevation (varies with the seasons) at the specific site. Solar maintenance activities include:

1. Clean the front surface of the solar modules with water and a suitable, non-abrasive extension brush. Avoid the use of any cleaning fluids that might leave a residue on the glass surface or promote corrosion of the support structure and its fasteners. Frequency of this activity is site and seasonal specific. Output from the solar modules that are professionally cleaned have upwards of 12% higher output power. Periods of rain showers tend to help keep the modules clean, whereas dusty periods or site locations dictate needs for more frequent cleaning.
2. Confirm the correct orientation and tilt angle of the array is consistent with the initial site orientation data established at the beginning of the project during the site survey. Assure mechanical fasteners are tight.
3. Inspect all electrical connections for looseness or corrosion.
4. Inspect the module back surface for damage or punctures. Seal any punctures that are found with a commercial grade non-acidic RTV sealant. If significant impact damage is observed, replace the affected solar module.

Battery Bank and Charge Controller

The solar controller maintains and controls battery charge by passing through energy from the solar controllers.

Important Battery Facts

Batteries store direct current electrical energy in chemical form for later use. In a solar power system, the energy is used at night and during periods of cloudy weather. Since a solar module system's power output varies throughout any given

day, a battery storage system can provide a relatively constant source of power when the module is producing minimal power during periods of reduced insolation. Batteries can even power the loads when the solar array is disconnected for repair and maintenance.

The lead acid-battery is the most commonly used type in the United States in both solar power system applications and in the automotive industry. Starting (sometimes called SLI, for starting, lighting, ignition) batteries are commonly used to start engines. Engine starters need very large starting currents for a very short time. In the construction of starting batteries, there are a large number of thin lead plates for maximum surface area. The plates are composed of a Lead "sponge", similar in appearance to a very fine foam sponge. This gives a large surface area, but if deep cycled, this sponge will quickly be consumed and fall to the bottom of the cells. Generally, automotive batteries will fail after 30-150 deep cycles if deep cycled, while they may last for thousands of cycles in normal starting use (2-5% discharge).

Deep cycle batteries are designed to be discharged to as much as 80% time after time, and have much thicker lead plates. The major difference between a true deep cycle solar battery and others is that the plates are SOLID Lead plates - not sponge. It is often impossible to tell the difference between the automotive and solar deep cell battery from the outside. However, it is critical to understand the differences between battery construction and use when specifying a system. Automotive batteries do not work well and have limited life if used in solar power systems.

Most battery manufacturers specify battery capacity in amp-hours. Many factors can affect battery capacity, including rate of discharge (from the load), depth of discharge, temperature, age, and recharging characteristics.

Life Expectancy

Most people think of life expectancy in terms of years. Battery manufacturers, however, specify life expectancy in terms of a quantity of cycles. Batteries lose capacity over time and are considered to be at the end of their life when 20% of their original capacity is lost.

Depth of discharge (DOD) refers to the percentage of original of a battery's rated amp-hour capacity that has been used. By contrast, say a battery experienced shallow cycling of only 25% DOD would be expected to last 4000 cycles at 25°C (77°F), the same battery cycled to 80% DOD would last 1500 cycles. With one cycle per day, the shallowly cycled battery would last for ~11 years while the deeply cycled battery would last for ~4 years.

It is recommended that the battery voltage be monitored on routine basis to assure that it is operating within design expectations. A battery voltage with a consistent downward tracking float voltage can be an early indicator that the battery is starting to near end of life. At a minimum, check battery voltage routinely to assure that the system voltage is trending flat not downward.

Environmental Conditions

Batteries are sensitive to their environment and are particularly affected by the temperature of that environment. Higher voltage charge termination points are required to complete charging as a battery's temperature drops (the opposite is true in warmer temperatures). Ventev power systems contain solar charge controllers that have an onboard temperature compensation feature which automatically adjusts battery charge voltage based upon a battery's temperature.

The battery capacity will decrease at lower (than 25°C, 77°F) temperatures and increase at higher temperatures. A battery at 32°F may be able to achieve only 65 to 85% of its fully rated capacity; at -22°F it may achieve only 50%. For this reason, it is critical to assure that the system load on a solar power system is properly sized for the correct Latitude, Solar Map Zone, and Load. A system undersized in any way may not operate well in colder temperatures.

Although battery capacity decreases as temperature drops below 77°F, battery life increases. Conversely, battery capacity increases with higher temperatures but battery life shortens. Many manufacturers claim a 50% loss in life for every 15°F increase over the standard 77°F cell temperature. For this reason, it is essential, for example, in Zone A, Southern California, and Southern Texas that battery life is monitored more frequently than other parts of the country. As far as capacity versus battery life, this tends to even out in most systems, as part of their lives is spent in higher temperatures and part in lower temperatures.

Battery maintenance activities include:

1. Periodically check all battery terminal connections for looseness and corrosion. Clean corroded terminals and tighten connections.
2. With a voltmeter, routinely measure and log the battery(s) voltage.
3. If the battery voltage has trended downward over time to near 80% capacity, initiate actions for battery replacement or contact TESSCO customer support .

System Wiring

System wiring should seldom cause a problem, but situations can arise whereby terminal corrosion can be detected before serious failures occur. During site visits:

- 1 Check all wiring for corrosion, insulation integrity, and damage.
- 2 Replace as necessary.

Appendix A Wiring Diagrams & Site Layout

Appendix A provides wiring diagrams for the various sized systems and a generic site layout. Wiring diagrams include:

- 12 Volt, 20-40 Watt, 18 Amp-Hr Systems
- 12 Volt, 10-40 Watt, 36 Amp-Hr Systems
- 12 Volt, 85-130 Watt, 198 Amp-Hr Systems
- 12 Volt, 170 Watt, 265 Amp-Hr System
- 12 Volt, 260-390 Watt, 420-530 Amp-Hr Systems
- 24 Volt, 80-130 Watt, 36 Amp-Hr Systems
- 24 Volt, 350-525 Watt, 210-265 Amp-Hr Systems
- 24 Volt, 175 Watt, 99 Amp-Hr System with 48 PoE Injector
- 24 Volt, 525 Watt, 265 Amp-Hr System with two 48 Volt PoE Injectors
- Site Layout

12 Volt, 20-40 Watt, 18 Amp-Hr System

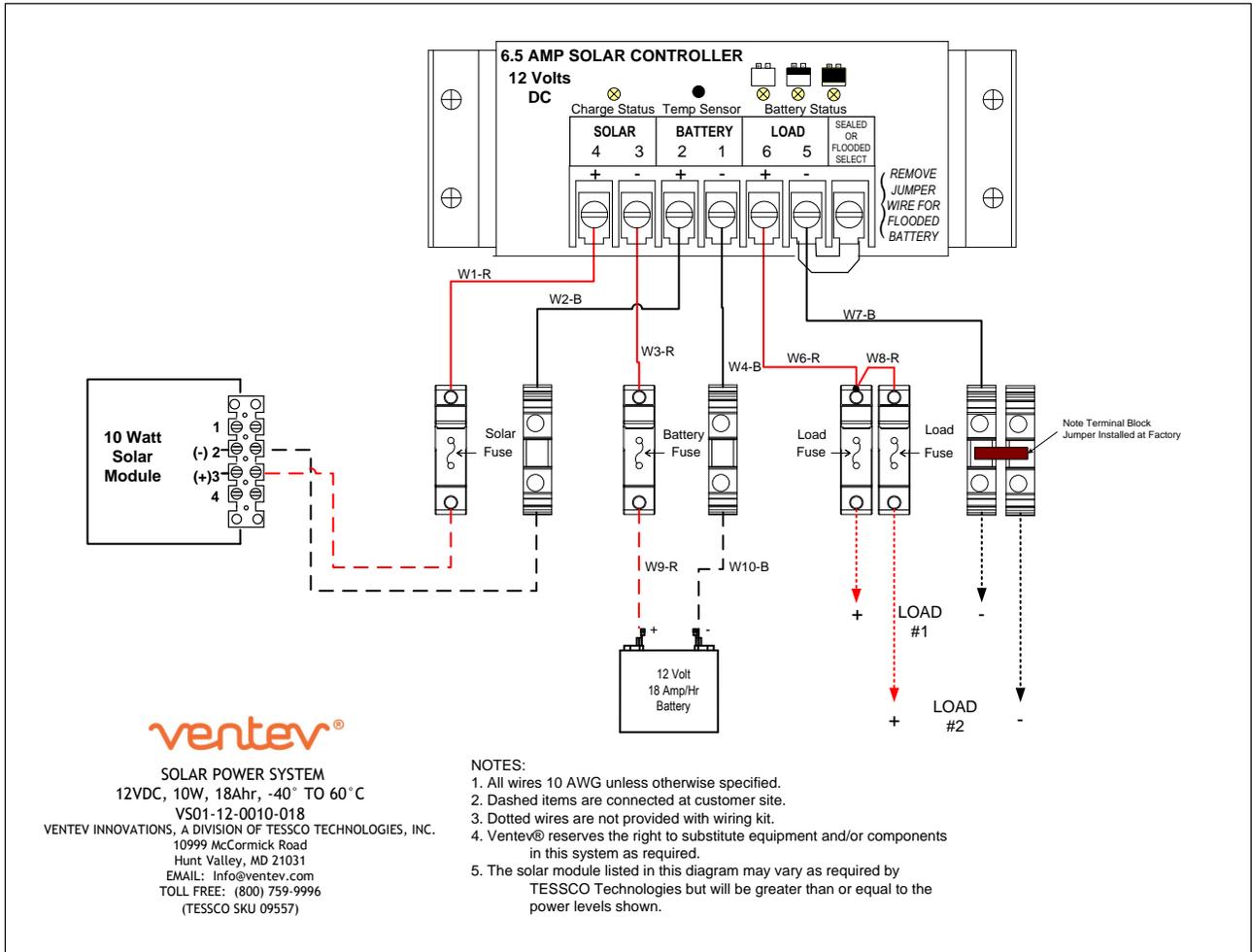


Figure 21: A Micro System. One of the 12 Volt 20 -40 Watt 18Amp-Hr Systems

The system wiring diagram in Figure 21 is a copy of the door wiring diagram for one of three systems of the Micro size. A pole mounted polycarbonate enclosure houses the solar controller, terminal and fuse blocks and factory wired components. Wires shown in solid lines are factory wired, dashed to be wired and connected in the field, and dotted (load) to provided by and connected by the customer. The solar module is also pole mounted, above the enclosure.

12 Volt, 10-40 Watt, 36 Amp-Hr Systems

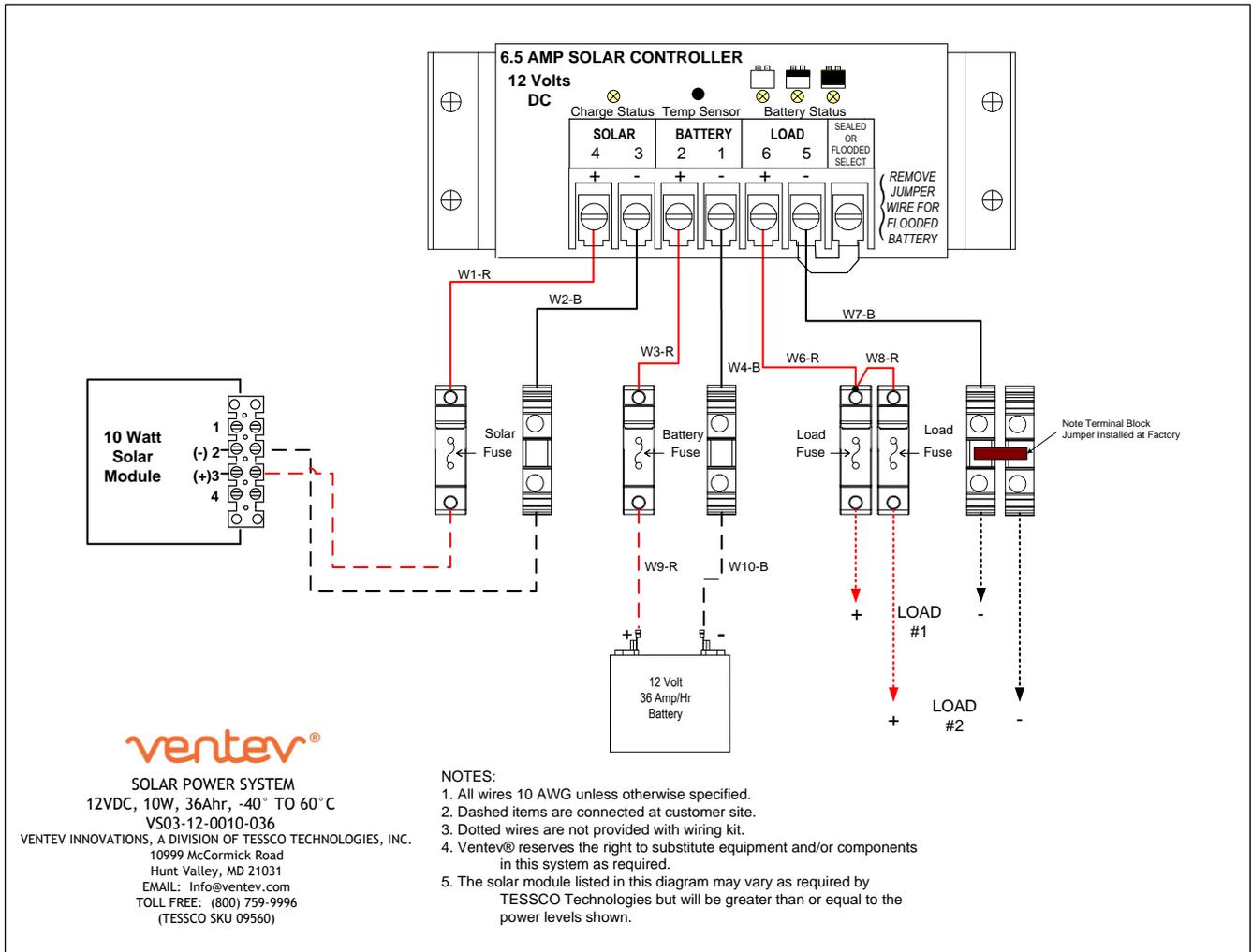


Figure 22: A Small System, One of the 12 Volt, 10 -40 Watt 36Amp-Hr Systems

Figure 22 is a copy of the door wiring diagram for one of four Small systems. A white powder coated aluminium enclosure houses the solar controller and associated wiring. The enclosure is pole mounted, typically on the same pole below the solar modules. Wires shown in solid lines are factory wired, dashed to be wired and connected in the field, and dotted (load) to be provided by and connected by the customer.

12 Volt, 85-130 Watt, 198 Amp-Hr Systems

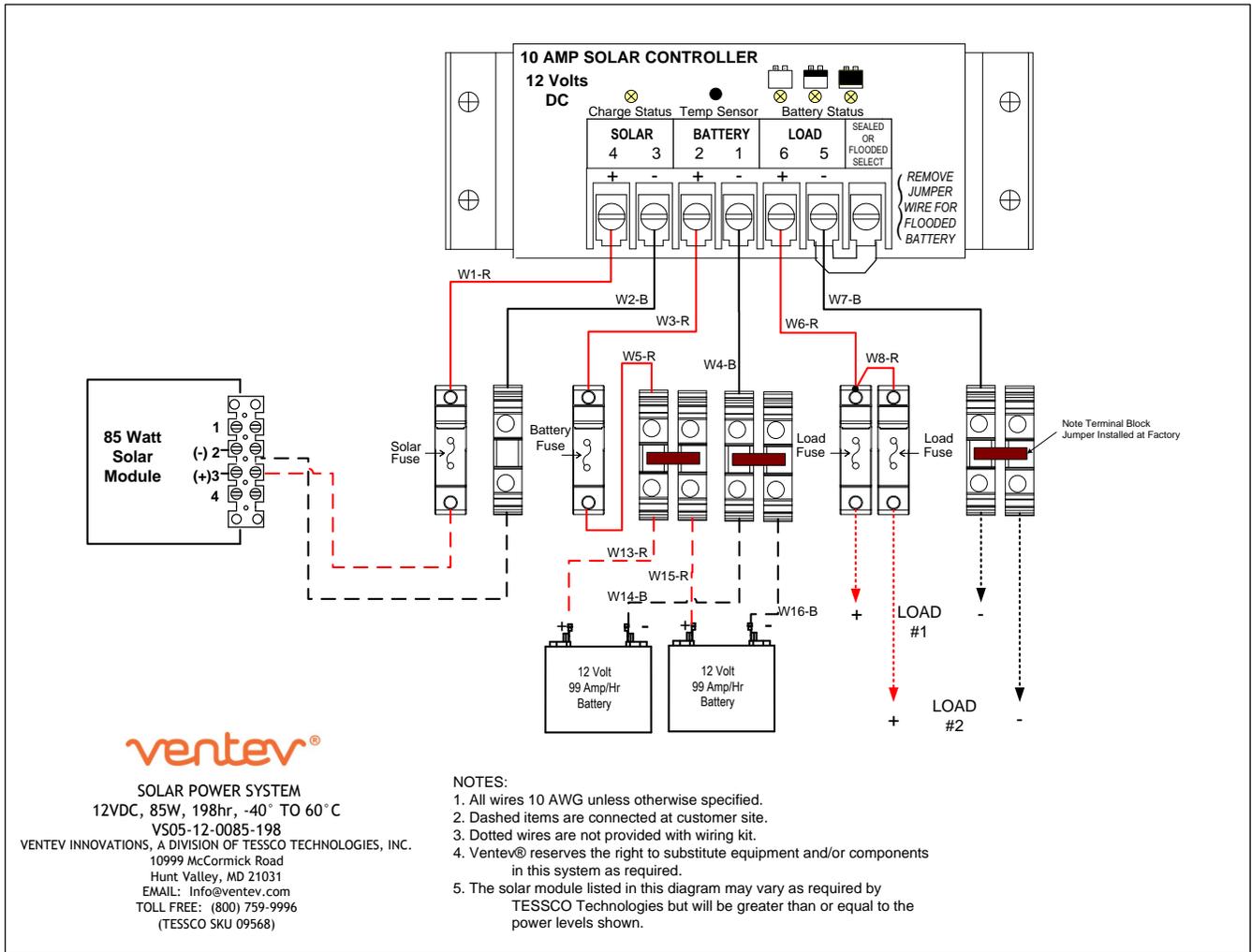


Figure 23: A Large System; one of the 12 Volt 85 to 130 Watt 198 Amp-Hr Systems

A copy of the door wiring diagram for a Large system is shown in Figure 23. This system houses a single solar controller module, but requires two batteries connected in parallel to achieve the required amp-hour rating. A white powder coated aluminium enclosure houses the solar controller and associated wiring. The enclosure is pole mounted, typically on the same pole below the solar modules. Wires shown in solid lines are factory wired, dashed to be wired and connected in the field, and dotted (load) to provided by and connected by the customer.

12 Volt, 170 Watt, 265 Amp-Hr System

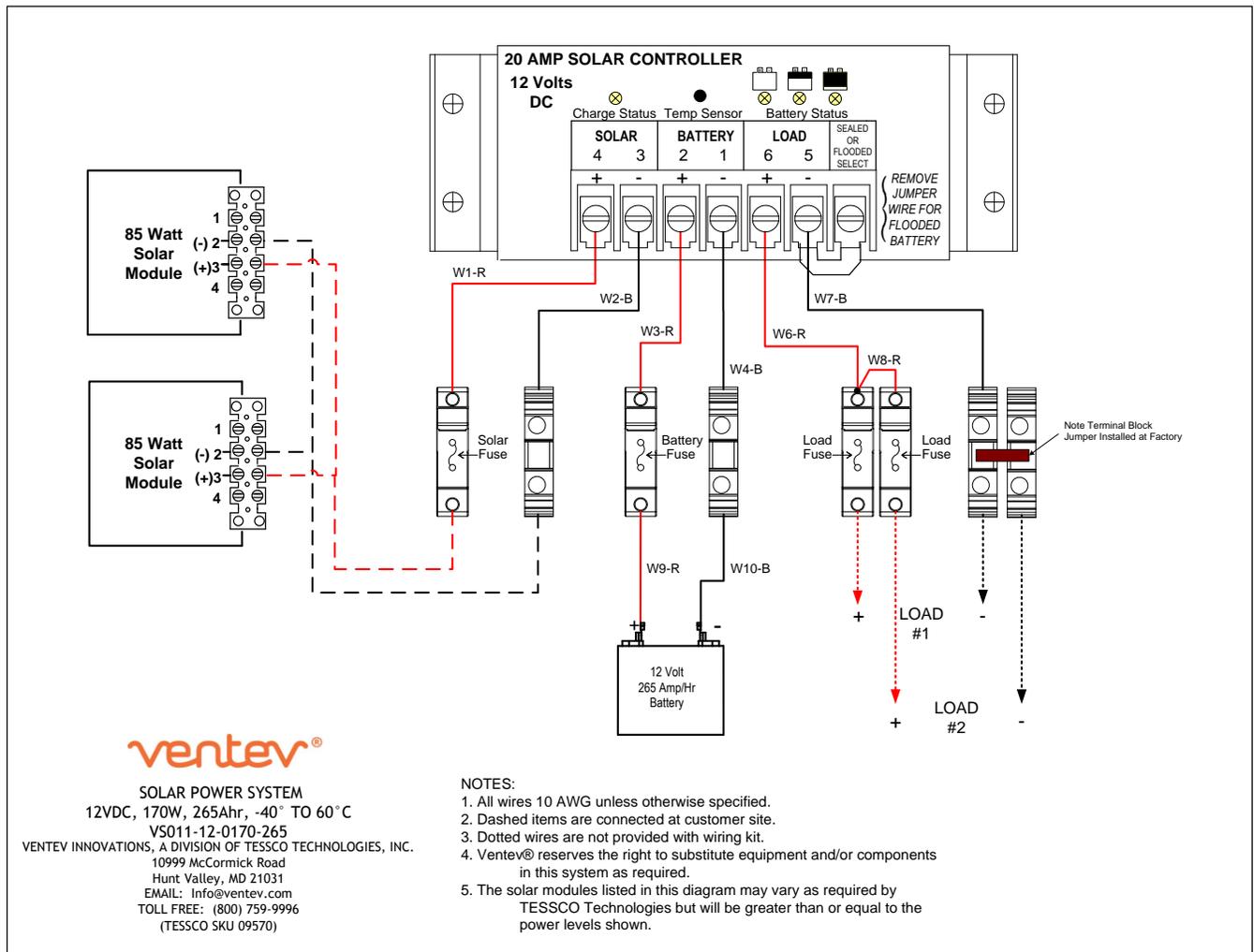


Figure 24: A Larger 12 Volt 170 Watt, 265Amp-Hr System

Figure 24 is a copy of the door wiring diagram for one of the larger systems containing one battery with two solar modules connected in parallel to give the required power needed for battery charging. A white powder coated aluminium enclosure houses the solar controller and associated wiring. The enclosure is pole mounted, typically on the same pole below the solar modules. Wires shown in solid lines are factory wired, dashed to be wired and connected in the field, and dotted (load) to provided by and connected by the customer.

12 Volt, 260-390 Watt, 420-530 Amp-Hr Systems

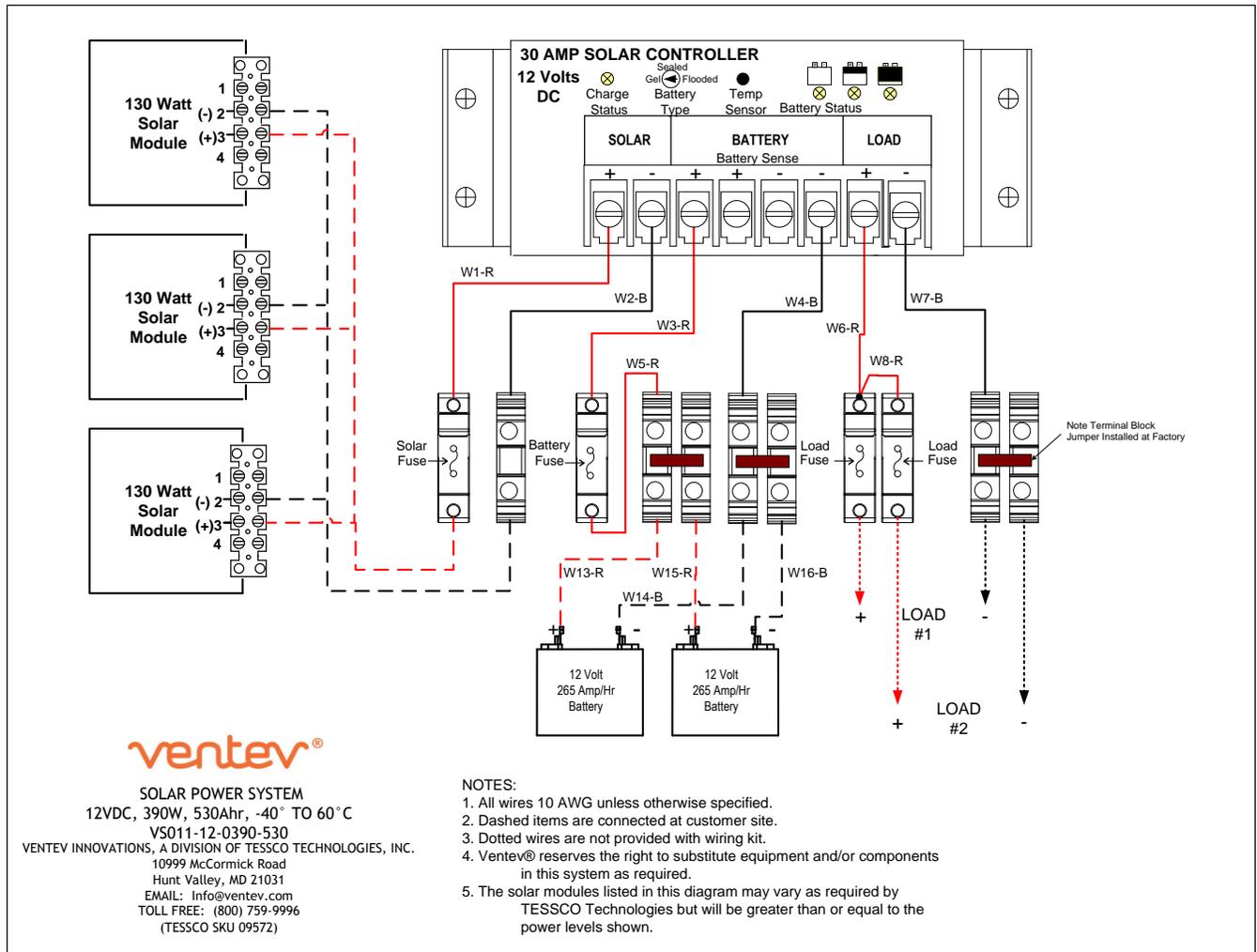


Figure 25: A large System; One of the 12 Volt 260 - 390 Watt 420 - 530Amp-Hr Systems

The door wiring diagram copy for the system shown in Figure 25 shows a system with multiple batteries and solar modules. A white powder coated aluminium enclosure houses the solar controller and associated wiring. The enclosure is pole mounted, typically on the same pole below the solar modules. Wires shown in solid lines are factory wired, dashed to be wired and connected in the field, and dotted (load) to be provided by and connected by the customer.

24 Volt, 80-130 Watt, 36 Amp-Hr Systems

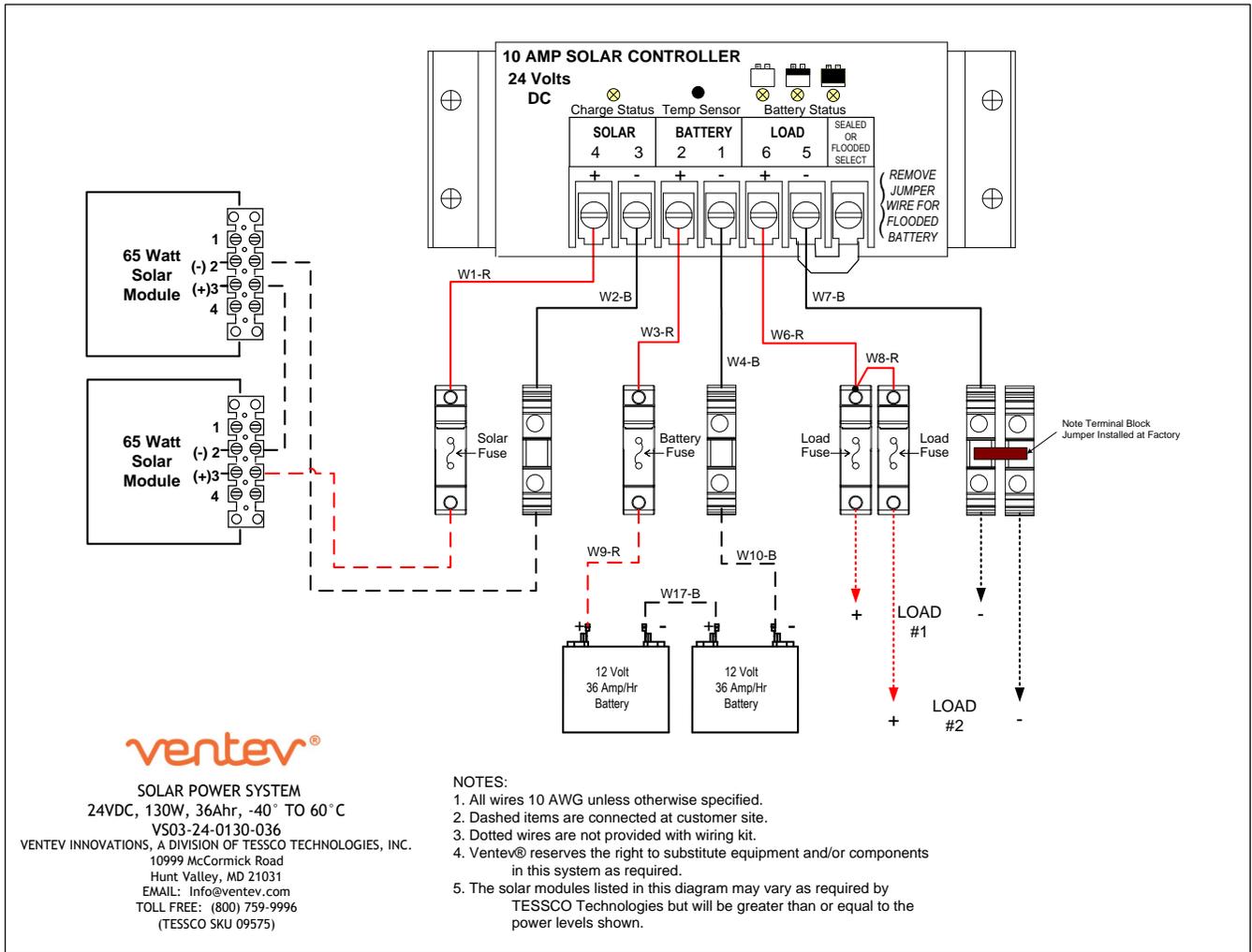


Figure 26: A 24 Volt System, one of the 24 Volt 80 -130 Watt 36Amp-Hr Systems

Figure 26 is a copy of the door wiring diagram for a 24 volt system. Note the parallel wiring of the 12 volt solar modules and 12 volt batteries to yield the necessary 24 volts for the solar controller. A white powder coated aluminium enclosure houses the solar controller and associated wiring. The enclosure is pole mounted, typically on the same pole below the solar modules. Wires shown in solid lines are factory wired, dashed to be wired and connected in the field, and dotted (load) to provided by and connected by the customer.

24 Volt, 350-525 Watt, 210-265 Amp-Hr Systems

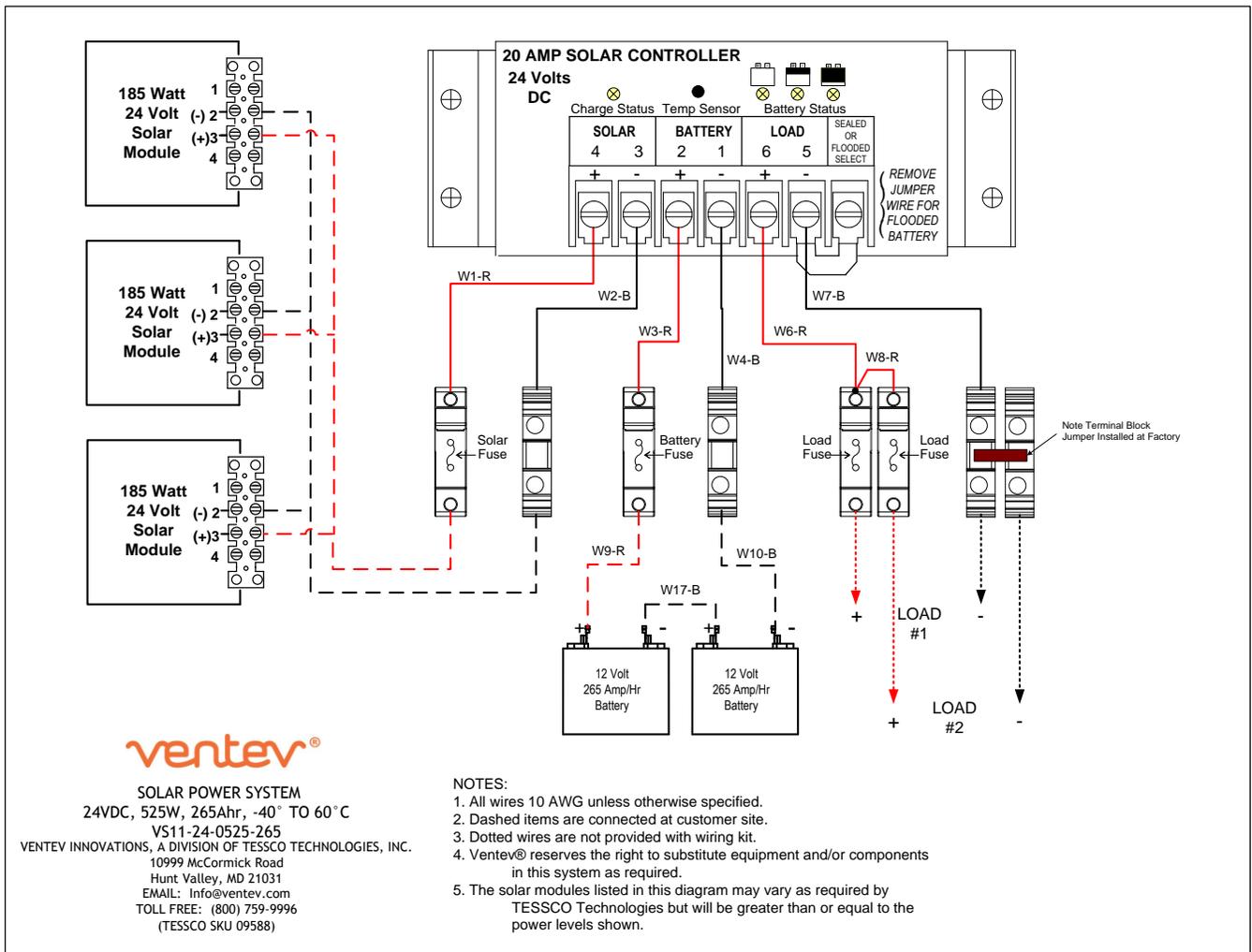


Figure 27: Extra Large System; one of the 24 Volt 35 - 525 Watt 210 - 265Amp-Hr Systems

Figure 27 is a copy of the door wiring diagram for an extra large system showing three 24 volt 175 Watt Solar Modules connected in parallel to provide the required power rating, and two 12 volt batteries connected in series to yield the required 24 volts. A white powder coated aluminium enclosure houses the solar controller and associated wiring. The enclosure is pole mounted, typically on the same pole below the solar modules. Wires shown in solid lines are factory wired, dashed to be wired and connected in the field, and dotted (load) to provided by and connected by the customer.

24 Volt, 175 Watt, 99 Amp-Hr System with 48 Volt PoE Injector

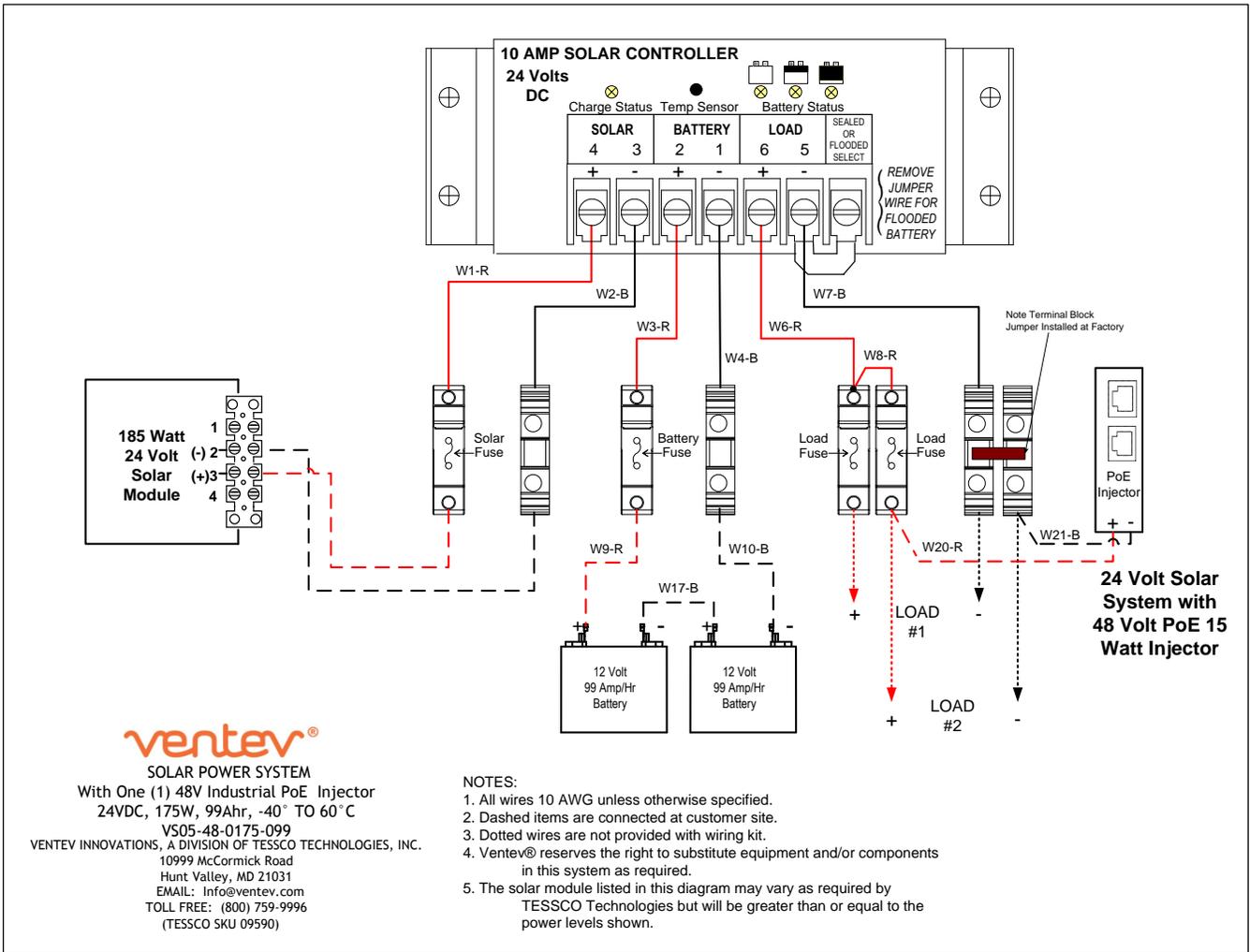


Figure 28: A large system with a 48 Volt Industrial PoE Injector

Power over Ethernet capability is shown in Figure 28 in the large system, a 24 Volt 175 Watt, 99 Amp-Hour system with a 48 Volt Industrial PoE Injector. A white powder coated aluminium enclosure houses the solar controller and associated wiring. The enclosure is pole mounted, typically on the same pole below the solar modules. Wires shown in solid lines are factory wired, dashed to be wired and connected in the field, and dotted (load) to provided by and connected by the customer.

24 Volt, 525 Watt, 265 Amp-Hr System with two 48 Volt PoE Injectors

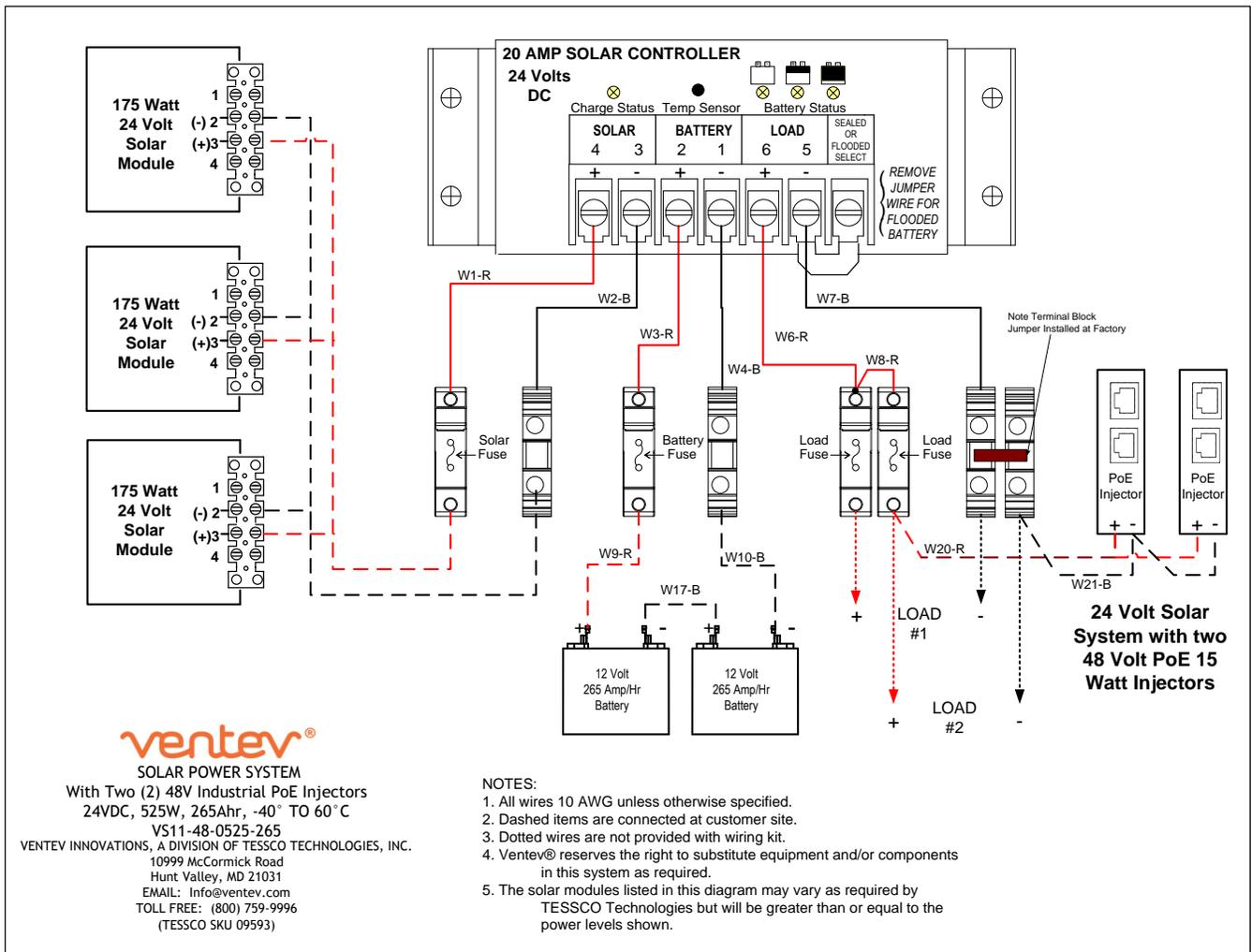


Figure 29: An Extra Large System with two 48 Volt PoE Industrial Injectors

Figure 29 is a copy of the door wiring diagram for a 24 volt, 525 watt, 265Amp-Hour system that contains two 48 Volt Industrial Power over Ethernet injectors. A white powder coated aluminium enclosure houses the solar controller and associated wiring. The enclosure is pole mounted, typically on the same pole below the solar modules. Wires shown in solid lines are factory wired, dashed to be wired and connected in the field, and dotted (load) to provided by and connected by the customer.

Site Layout

The following illustration shows the basic architecture of components installed at a site. The angle of the solar module will vary depending on location.

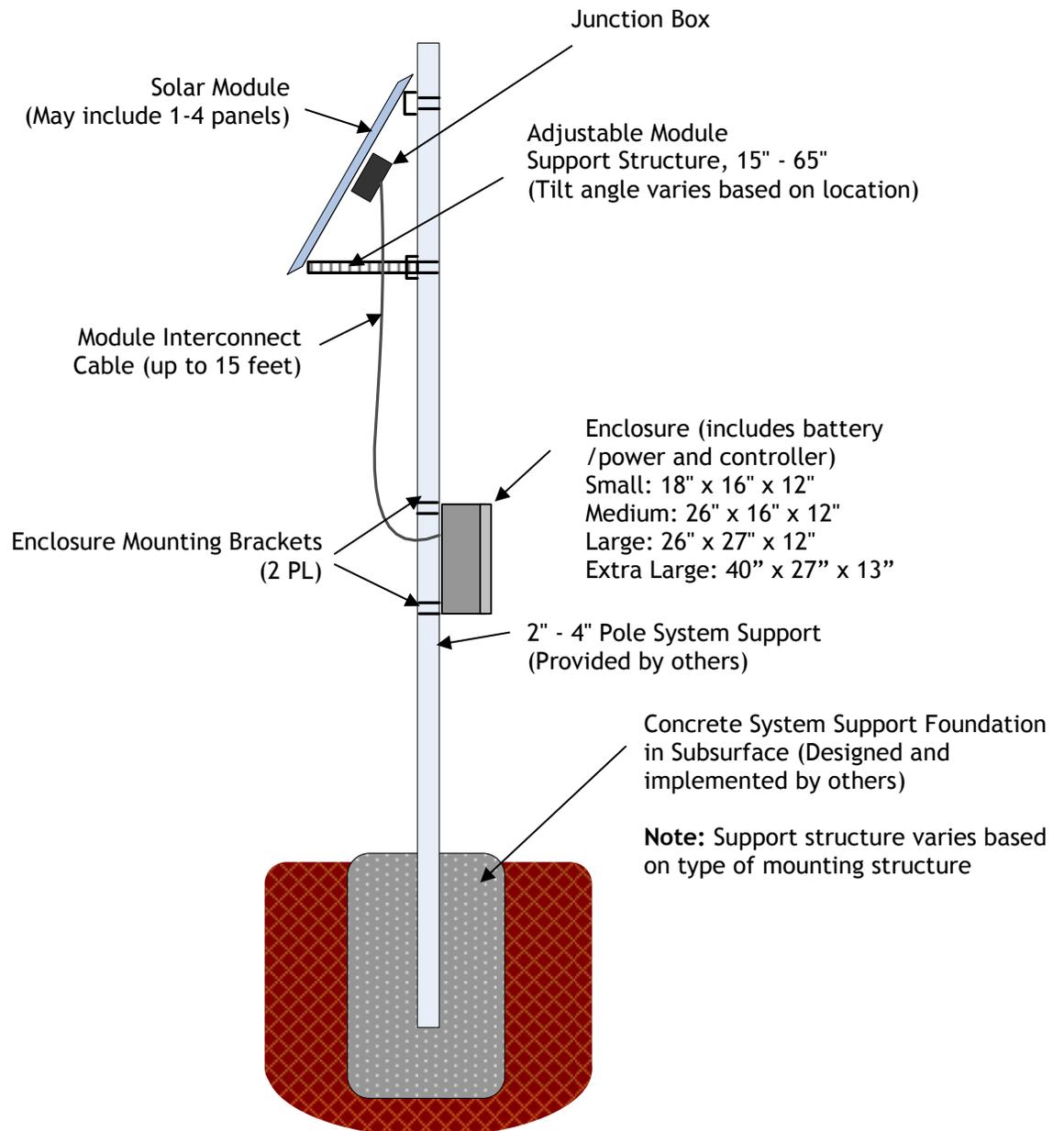


Figure 30: Site Layout

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Ventev Innovations
(A Division of TESCO Technologies)
10999 McCormick Rd
Hunt Valley, MD 21031
Phone +1 (800) 759-9996

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