South Coronado Power Supply System

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La Jolla, Ca 92093-0213

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1. Summary

As part of an innovative approach to monitor and assess San Diego's coastal waters extending 30 Kilometers off the coast, the San Diego Coastal Ocean Observing System (SDCOOS – http://www.sdcoos.ucsd.edu) was established. Scripps Institution Of Oceanography, in a partnership with The State of California, City of Imperial Beach, and the San Diego County Department of Environmental Health developed, installed, and currently operates a coastal monitoring and observing system.

The backbone of the Coastal Ocean and Observing System is an array of high-frequency radars designed to provide a spatial map of the local ocean surface currents on a real-time basis. An immediate application of the current maps is to use the data as a framework for interpreting results from water quality testing programs that are already in place. Because real-time data is available on the web, there is a broad end-user community including scientists, policy and decision makers (city/state), public health responders as well as the general public. The radar array is composed of three sites located at: Border Field State Park, Point Loma, and South Coronado Island on Mexican property. The decision to operate a site on the remote Coronado Island was based on the geometry of the radar array. This site allowed for more accurate determinants of surface currents.

The remoteness of the island dictated that we find an alternative energy source to power the CODAR system. This document represents the research and development evolution of the solar system currently in use on South Coronado Island.

Logistic Timetable

October 2, 2002: South Coronado inspected. Solar system location established.
December 2, 2002: Solar sub-structure installation initiated.
January 16, 2003: Solar sub-structure completed.
February 3, 2003: Solar panels installed.
February 14, 2003: Helicopter drops of solar system equipment.
February 20, 2003: Wind generator installed, final preparation for system initiation.
February 24, 2003: Solar system complete, system producing 24 VDC.
March 11, 2003: CODAR installed, Wireless links complete and transmitting data.
June 27, 2003: Meteorological station complete and transmitting data.

2. System Requirements

2.1 CODAR Power Consumption

CODAR estimated that the 24 volt system consumes 250 watts continually. This includes the radar transmitter, receiver and the system laptop.

2.2 Auxiliary Electrical Power Consumptions

In addition to the CODAR components mentioned in section 2.1, power consumption requirements for additional scientific instrumentation are described below.

Net Gear switch: 7.5 continuous watts
COR: 25 continuous watts
Amplifier: 10 continuous watts
Cambell meteorological logger: 28 continuous watts
Wavelan: 5.2 continuous watts

2.3 Operational Needs and Considerations

The entire solar system was designed around the newly developed 24 volt CODAR system. The system was developed to produce enough energy for all scientific instrumentation with a surplus of energy for future endeavors.

3. System Location

3.1 General Information

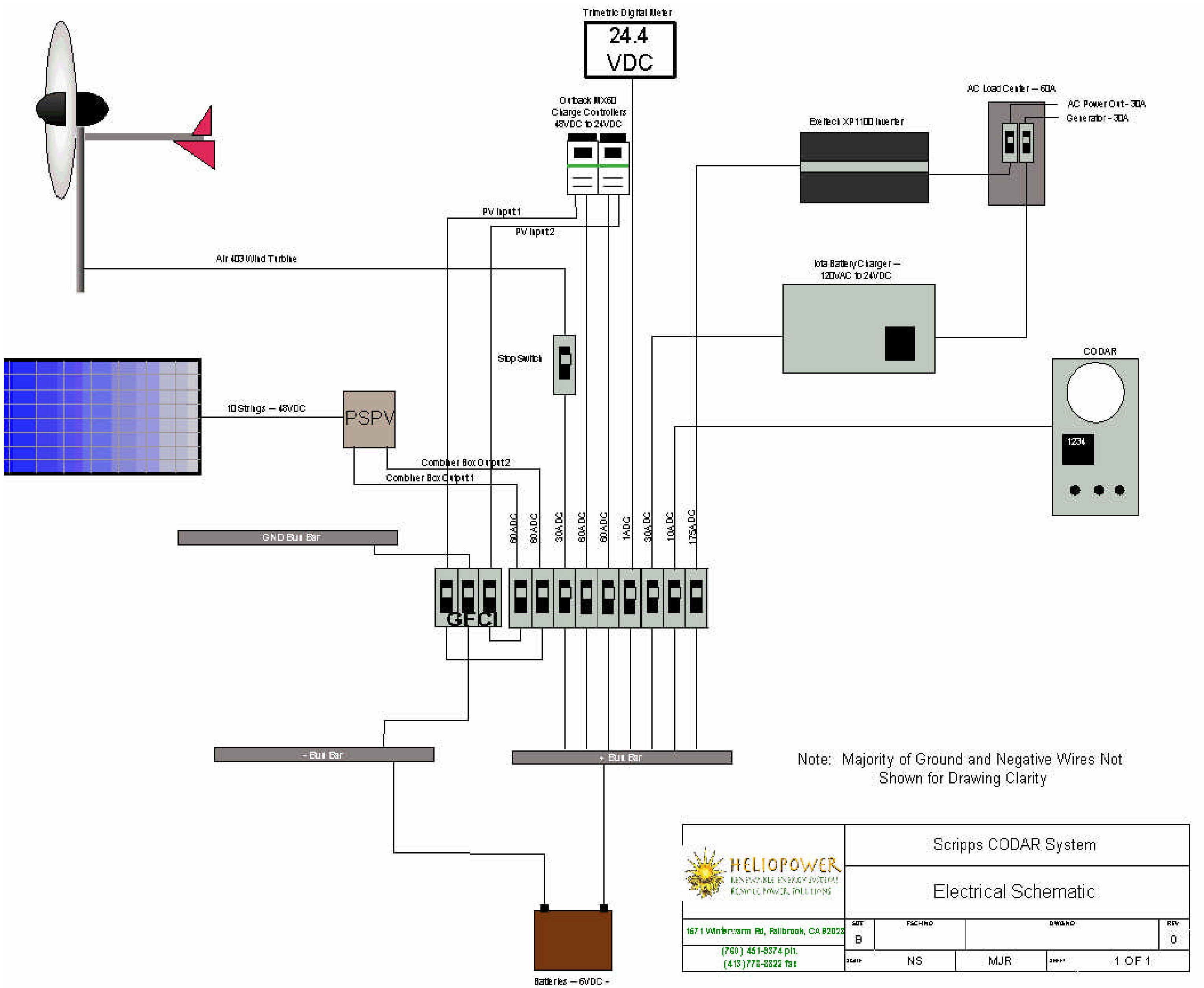
Level ground and available space on the island dictated the placement of the solar array. The solar array was placed to the North of an existing concrete structure. The concrete structure would eventually serve to house the CODAR enclosure. Solar system components were placed under the panels in two separate weather-proof enclosures.


3.2 System Specifications

In order for our solar system to accommodate our needs there were a variety of requirements that went into the design and implementation of the system.. Based on the consumption estimates for both CODAR and auxiliary components (See section 2.1 and 2.2), we designed the solar system to be capable of producing 500 continuous watts, which would supply both our immediate and future power requirements on the island. The system had to supply power to CODAR and auxiliary components continuously with zero down time. Because of the remote location of the island, the system had to be highly reliable. With this in mind we designed the system to generate power with solar and wind components. We also installed an additional component, which allows us to charge the system with a generator if needed (See section 4).

4. System Design

4.1 System Diagram



4.2 Battery Sizing For Load

4.2.a. System Sizing Worksheet

Battery Sizing			
Average Daily Load	Inverter Efficiency	DC System Voltage	Average Amp-Hours/Day
12000	0.9	24	500.00
Days of Autonomy	Discharge Limit	Battery Amp-Hour Capacity	Batteries in Parallel
1.00	0.5	370	3.00
DC System Voltage	Battery Voltage	Batteries in Series	Total Batteries
24	6	4	12

Renewable Energy Systems/Remote Power Solutions
"Putting the Power of Nature to Work for You"

HelioPower
550 Industrial Way, Unit C
Fallbrook, CA 92028
Phone: (760) 451-9374
Fax: (760) 451-9393
www.heliopower.com

Fig. 1 Calculations Supplied By HelioPower

4.2.b. General Information

The battery sizing calculations aided us in determining the quantity of batteries needed for our application. We wanted our battery bank to give us one day of autonomy. We also had to produce a battery bank that gave us the required 24 VDC for our CODAR system. We designed our battery bank to have a 50% state of discharge at the end of the day.

4.2.c. Batteries

Based on our battery requirements, the Surrette S-460 was the battery of choice. These are 6 volt deep cycle solar batteries (See section 7 for specifications). Based on our calculations, it was determined we would need 12 batteries (See Fig 1). The batteries were placed in series of four giving our necessary 24 volts, which were then placed in a parallel grouping, thus providing the 24 volts dc from three separate series.

Fig. 2 Battery bank showing series and parallel configurations. 1-4, 5-8, and 9-12 are configured in series, each giving 24 volts DC. These three series are then paralleled.

4.2.d. Battery Housing

The batteries are housed in a converted Knaack box, (model #3068). The shelf within the box was cut out to provide sufficient space for the 12 solar batteries. A stainless steel vent was also installed to prevent hydrogen gas build up (See figure 5).

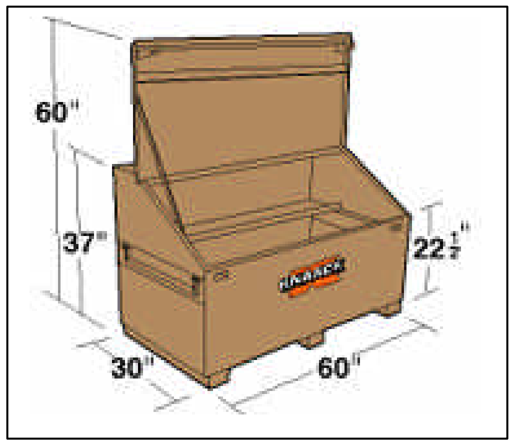


Fig. 3 Knaack box (Model #3068)

Fig. 4 Knaack box prior to primer and paint

Fig. 5 Knaack box ready for battery storage.

4.3. Array Sizing For Battery Charging

Array Sizing			
Average Amp-Hours/Day	Battery Efficiency	Peak Sun Hours/Day	Required Imp Array
500.00	**0.9**	**6**	**92.59**
Peak Amps/Module	Modules in Parallel	DC System Voltage	Nominal Module Voltage
4.45	**21**	**24**	**24**
Modules in Series	Modules in Parallel	Total Modules	
1	**21**	**21**	

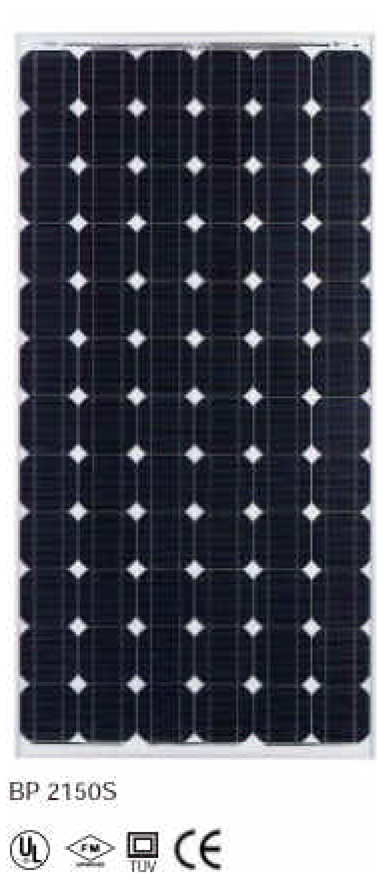
Fig. 6 Calculations Supplied By HelioPower

4.3.a. General Information

Because of the marine enviroment and obscure light conditions from occassional ocean fog, we selected monocrystalline solar panels. Our panels were wired in a 48volt DC configuration to take advantage of Maximum Power Point Tracking (MPPT) capabilities present in our charge controllers (See section 4.5). The solar array was placed facing due South and fixed at 30°. Because of limited space on the island, the final location of the solar array had the potential for afternoon shadowing by a nearby mountain. The performance of the panels has proved to be sufficient to meet our power demands.

4.3.b. Solar Panels

Based on environmental and solar characteristics of the area, we selected BP 2150S' solar panels from BP Solar. These panels are composed of 72 monocrystalline silicon solar cells in series. BP solar claims they have the strongest frames in the industry and the weatherproof connectors make them an ideal choice for the island environment. These panels have a maximum output of 150 watts each panel. Our array-sizing chart (See figure 6) indicated we would need 21 panels, but we used 20. We opted for the additional power to be supplied by a wind generator (See section 4.4), which was a logical choice on the wind-swept South Coronado Island.



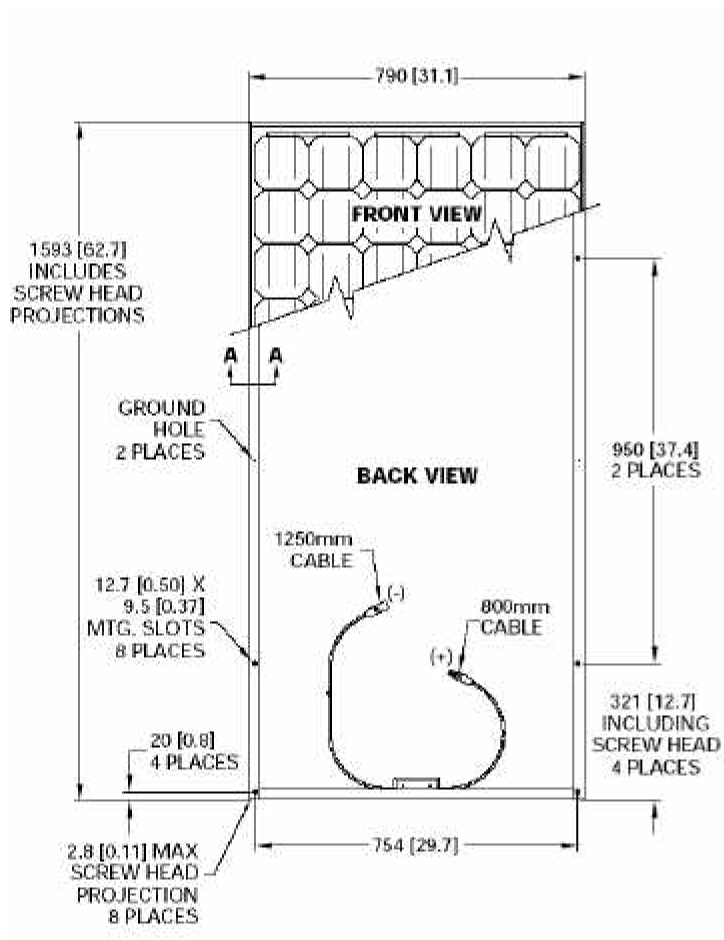


Fig. 8 BP 2150S **Fig. 9 Mechanical Drawing Of BP 2150S**

4.3.c. Solar Panel Combiner Box

An Outback PSPV combiner box was used to combine the solar panels and bring two lines of 48 volts to the charge controllers. As mentioned in section 4.3.a., we wired the solar panels in a 48 volt configuration to take advantage of the MPPT capabilities of our Outback MX 60 charge controllers. The combiner box can hold up to 12 breakers. We used 10 Outback OBPV 10 amp breakers to accommodate our 10 strings of 48 volt dc.

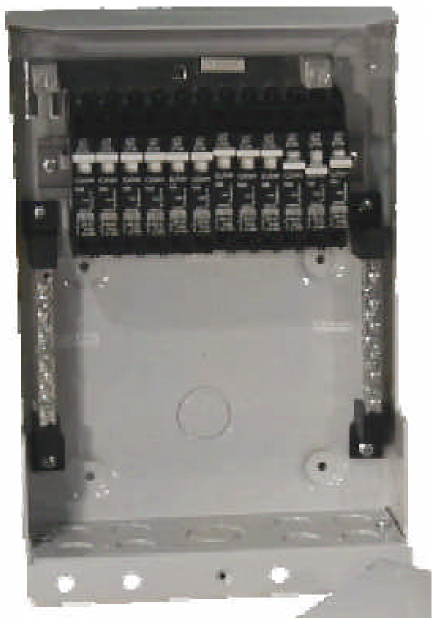


Fig. 10 Outback PSPV combiner box with twelve breakers installed

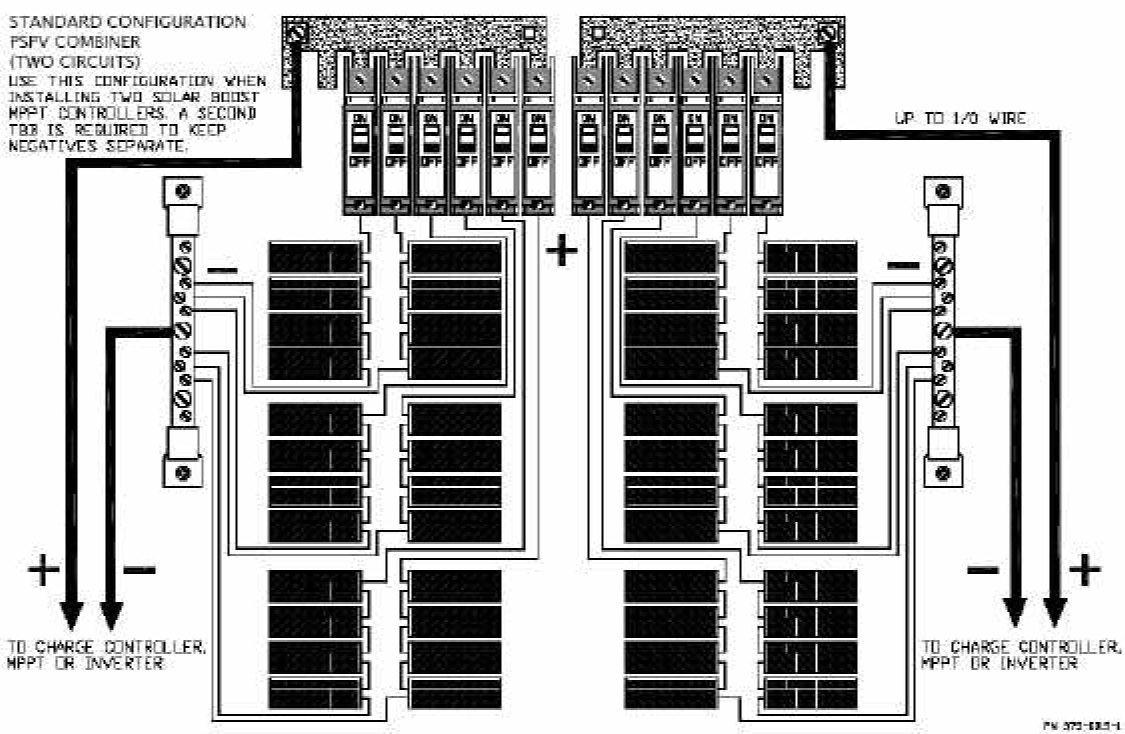


Fig. 11 General wiring diagram for the PSPV showing two circuits, representing our two lines of 48 vdc output to the charge controllers.

4.3.d. Solar Panel Mounting System

For mounting the solar panels we needed a system that was easy to transport by boat, easily put together, and strong enough to withstand strong winds, which occur frequently on South Coronado Island. The terrain is very rocky in the area we allocated for the solar array. We therefore had to consider which mounting system was most easily secured to the ground. Taking all of these factors into consideration, we selected Ground Trac by Professional Solar Products. This mounting system is composed of lightweight aluminum rails, which can then be easily clamped onto a pipe sub-structure. The solar panels are then secured to the rails with patented Slide-n-Clamps. This system requires two days for installation and is relatively easy to assemble. Posts for supporting the substructure are set in concrete the first day, followed by the assembly of the rest of the system the second day. For the sub-structure, we used 11/4" schedule 40 aluminum pipe. We selected aluminum for its reduced weight and its ability to better withstand corrosion in the marine environment.

Fig. 12 Ground Trac System by Professional Solar products, showing aluminum support rails, and pipe sub-structure

Fig. 13 Ground Trac system being assembled.

Fig. 14 Solar panels secured to Ground Trac system.

4.4. Wind Turbine

4.4.a. General Information

According to the array-sizing chart (see figure 6), our system called for 21 solar panels. Instead, we went with 20 panels and supplemented the system with a 24-volt wind turbine. The Coronado Islands regularly receive strong winds, so the use of a wind turbine to make up the additional energy needed was a logical choice.

4.4.b. Air-X Marine

The Air-X Marine by Southwest Wind Power was our wind turbine of choice. The construction of the turbine with aluminum and stainless parts makes it ideal for the marine environment. The Air-X was specifically designed for coastal and marine environments where corrosion is a concern. This unit comes equipped with an internal voltage regulator, which automatically stalls blades in high winds and in situations where voltage is at required level. The minimum of moving parts and ease of installation was an added bonus.

Fig. 15 Air-X On South Coronado Island

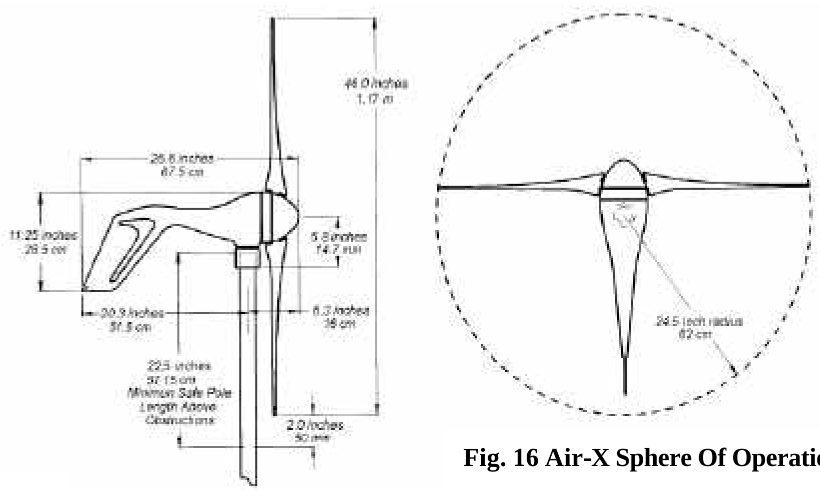


Fig. 16 Air-X Sphere Of Operation

4.5. Charge Controllers

4.5.a. General Information

Charge controllers are necessary components of a solar power system. A charge controller monitors the voltage coming from the solar panels and keeps a steady voltage going to the battery bank. Voltages sent to the batteries depend on the type of battery. In our case, Charge controllers received voltage from a 48-volt solar array and supplied our battery bank with a steady 24 volts. We selected the Outback Power Systems MX60 as our charge controller. Because of the amperage of our system, we had to use two charge controllers.

4.5.b. Outback Power Systems MX60

The Outback Power Systems MX60 has MPPT (See sec.4.3.a.). This feature allows our PV system to achieve its highest possible performance. The MX60 comes equipped with fully adjustable set points and can be used with most battery types. The MX60 also allows for a higher output voltage on the solar array, while charging the battery bank at a lower voltage. We took advantage of this capability with our solar array set at 48 volts D.C. and our battery bank is charged at 24 volts DC. This capability allows for reduced wire size and also reduced power loss from the solar array to the charge controllers. The four line, 80 character backlit display allows for simplistic programming and monitoring.

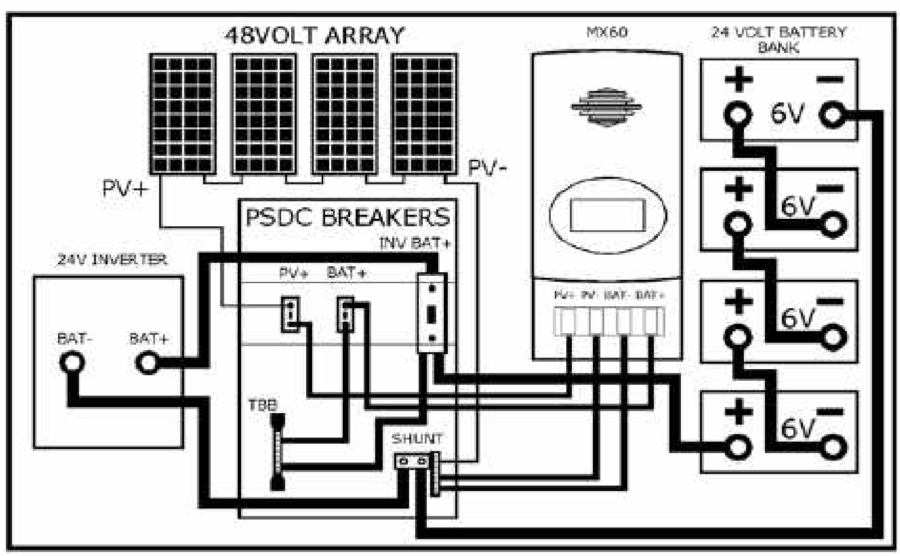


Fig. 17 MX60 in schematic showing wiring similar to our system.

ig. 18 Outback Power Systems MX60 Charge Controller

4.6. Inverter

4.6.a. General Information

Our system includes a D.C. to A.C. inverter. We installed this component because of the lack of electricity on the island. As long as our system is operational we can utilize the solar power to operate equipment that requires A.C. input. This inverter eliminates the need for hauling a generator back and forth from the island.

4.6.b. Exeltech XP 1100

We selected the Exeltech XP 1100 as our inverter. This inverter provides a clean, regulated sine wave. It allows for a wide range of DC input. Our inverter has the capability of 1100 Watts continuously at 30° C. This inverter comes equipped with over and under voltage protection and also comes with over temperature protection.

Fig. 19 The Exeltech XP 1100

4.7. Battery Charger

4.7.a. General Information

In addition to the inverter (See sec. 4.6), a battery charger was also incorporated into the system (See sec. 4.1). This allows us to charge the batteries, using a generator, if a problem occurs with the solar array. The battery charger converts 120 VAC to 24 vVDC.

4.7.b. Iota Engineering DLS-27-25

We selected the Iota Engineering DLS-27-25 battery charger. It has a wide range of input voltages and comes equipped with many protection systems. It has short circuit protection, reverse polarity protection, and thermal protection. With a normally operating system this component is not necessary, but the remote location of the system requires that we have back-up systems in place.

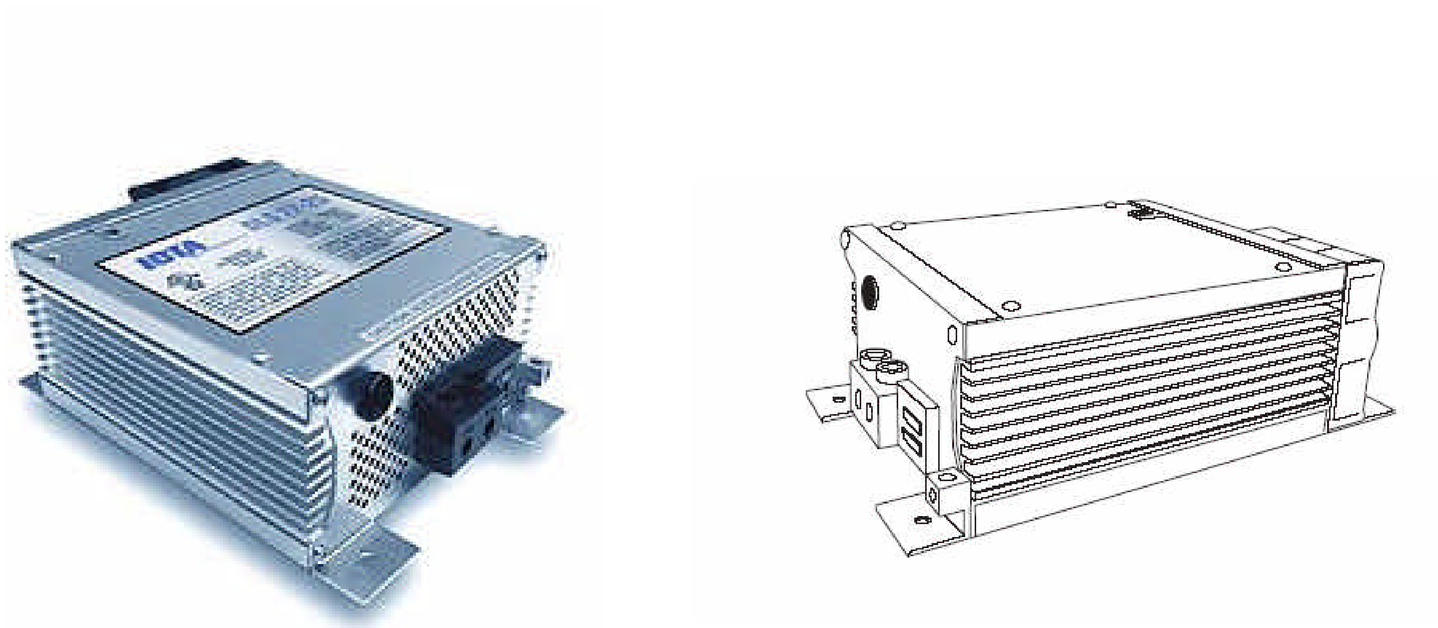


Fig. 20 The Iota Engineering DLS-27-25 Battery Charger.

4.8. Power Center

4.8.a. General Information

For all of these components it was necessary to house them in a centralized location. To safeguard them against weather we decided to have a custom weatherproof enclosure built that would accommodate all the components of the system mentioned in sections 4.5-4.7.

4.8.b. Enclosure

The enclosure was built with aluminum and powder-coated to make it weather proof. Dimensions were specifically tailored to accommodate all the components that were to be housed within it (See figure 21).

Fig. 21 Inside and Outside Views Of Weather-Proof Enclosure.

4.8.c Power Center Equipment

The following are housed within the power enclosure: Outback PSDC, Outback charge controllers, Exeltech power inverter, Iota battery charger, and the Tri-Metric battery state meter. The Outback PSDC serves as a load center for all of the components in the solar array system. This houses wiring and circuit breakers for each of the components in the system. The PSDC provides disconnect capability, over-current protection, and grounding components all within a single, easily accessible enclosure. The PSDC also provides areas to which charge controllers can be attached (See figure 22).
For a detailed description see section 4.1. The Tri-metric battery state meter is an extra device that gives us a digital read-out of battery status (See figure 22).

Fig. 22 Inside Enclosure Detailing Various Components

5. Summary

In summary, the remote location of the project has been the source of several obstacles in deploying this system. The initial permissions and the transport of the equipment to South Coronado presented the greatest obstacle. Currently the system is running smoothly and requires little maintenance. Routine trips are made to the Island for topping off water in batteries, cleaning solar panels, and computer upgrades. The stability of this system and the data we have received is attributed to the hard work and dedication to all those involved. Special thanks to Mo Rousso and Heliopower for their help on design and installation.

6. Specification Sheets

Batteries

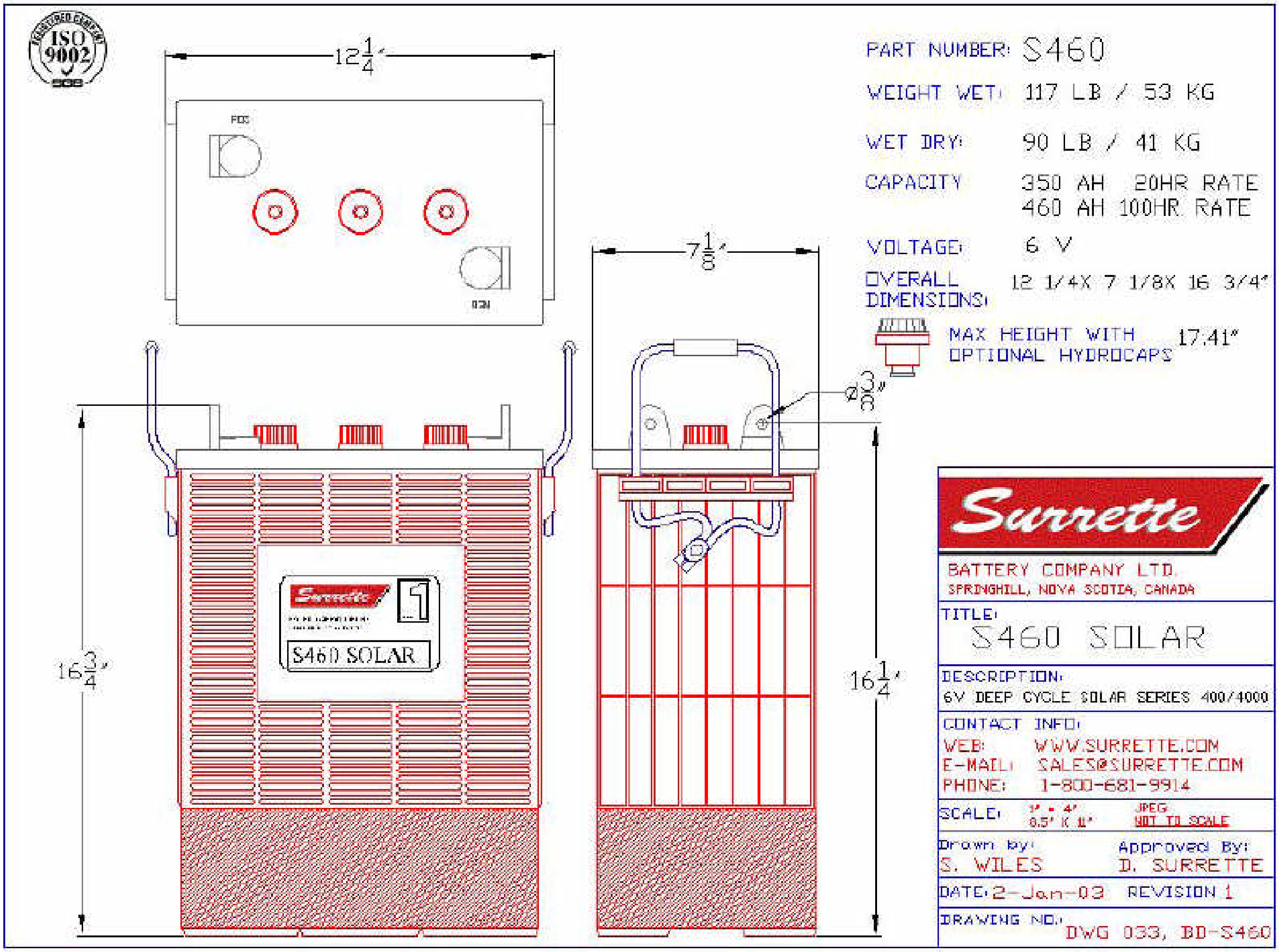
Surrette

DEEP CYCLE-SOLA

SERIES 40

BATTERY TYPE		VOLTS	6		**S-460**	
DIMENSIONS						
LENGTH				311 MM	12 1/4	INCHE
WIDTH				181 MM	7 1/8	INCHE
HEIGHT				425 MM	16 3/4	INCHE
WEIGHT DRY				41 KG	90	LBS.
WEIGHT WET				53 KG	117	LBS.
CONTAINER CONSTRUCTION						
CONTAINER		HIGH DENSITY POLYPROPYLENE				
COVER		HIGH DENSITY POLYPROPYLENE				
HANDLES		ROPE				
PLATES PER CELL				15		
ELECTROLYTE RESERVE	ABOVE PLATES			32 MM	1.25	INCHE
DESIGN CRITREA	7 YEAR WARRANTY		1300	CYCLES	10	YEAR
POSITIVE PLATE DIMENSION						
HEIGHT				273 MM	10.750	INCHE
WIDTH				143 MM	5.625	INCHE
THICKNESS				4.32 MM	0.170	INCHE
NEGATIVE PLATE DIMENSION						
HEIGHT				273 MM	10.750	INCHE
WIDTH				143 MM	5.625	INCHE
THICKNESS				3.05 MM	0.120	INCHE
SEPARATOR	SEPARATOR THICKNESS			0.081 INCH		
INSULATION	0.020" GLASS MAT					
TERMINALS	AUTO POST					
COLD CRANK	CCA	0°F / -17.8°C	1066	**RESERVE**		761
	MCA	32°F / 0°C	1333	**MINUTES AT 25A**		
CAPACITY	20 HR RATE		350			

		CAP / AH	CURRENT / AMPS
CAPACITY AT THE 100 HOUR RATE	1.265 SP. GR.	466	4.66
CAPACITY AT THE 72 HOUR RATE	1.265 SP. GR.	441	6.13
CAPACITY AT THE 50 HOUR RATE	1.265 SP. GR.	417	8.33
CAPACITY AT THE 24 HOUR RATE	1.265 SP. GR.	361	15.0
CAPACITY AT THE 20 HOUR RATE	**1.265 SP. GR.**	**350**	**17.5**
CAPACITY AT THE 15 HOUR RATE	1.265 SP. GR.	329	21.9
CAPACITY AT THE 12 HOUR RATE	1.265 SP. GR.	312	26.0
CAPACITY AT THE 10 HOUR RATE	1.265 SP. GR.	298	29.8
CAPACITY AT THE 8 HOUR RATE	1.265 SP. GR.	280	35.0
CAPACITY AT THE 6 HOUR RATE	1.265 SP. GR.	259	43.2
CAPACITY AT THE 5 HOUR RATE	1.265 SP. GR.	245	49
CAPACITY AT THE 4 HOUR RATE	1.265 SP. GR.	228	57
CAPACITY AT THE 3 HOUR RATE	1.265 SP. GR.	207	69
CAPACITY AT THE 2 HOUR RATE	1.265 SP. GR.	179	89
CAPACITY AT THE 1 HOUR RATE	1.265 SP. GR.	126	126


ISO 9002
12 1/4"
7 1/8"
16 3/4"
16 1/4"
⌀3/8"
S460 SOLAR
PART NUMBER: S460
WEIGHT WET: 117 LB / 53 KG
WET DRY: 90 LB / 41 KG
CAPACITY 350 AH 20HR RATE
460 AH 100HR RATE
VOLTAGE: 6 V
OVERALL DIMENSIONS: 12 1/4X 7 1/8X 16 3/4"
MAX HEIGHT WITH OPTIONAL HYDROCAPS 17.41"
Surrette
BATTERY COMPANY LTD.
SPRINGHILL, NOVA SCOTIA, CANADA
TITLE: S460 SOLAR
DESCRIPTION: 6V DEEP CYCLE SOLAR SERIES 400/4000
CONTACT INFO:
WEB: WWW.SURRETTE.COM
E-MAIL: SALES@SURRETTE.COM
PHONE: 1-800-681-9914
SCALE: JPEG NOT TO SCALE
Drawn by: S. WILES
Approved By: D. SURRETTE
DATE: 2-Jan-03 REVISION 1
DRAWING NO.: DWG 033, BD-S460

Solar Panels

Quality and Safety

All BP 2150 products are manufactured in BP Solar's ISO 9001-certified factories and conform to European Community Directives 89/33/EEC, 73/23/EEC, and 93/68/EEC. The BP 2150S and 2150U are:

- Listed by Underwriter's Laboratories for electrical and fire safety (Class C fire rating);
- Certified by TÜV Rheinland as Class II equipment;
- Approved by Factory Mutual Research for applications in NEC Class 1, Division 2, Groups C & D hazardous locations;
- Certified as complying with the requirements of IEC 61215, including:
  - repetitive cycling between -40°C and 85°C at 85% relative humidity;
  - simulated impact of 25mm (one-inch) hail at terminal velocity;
  - a "damp heat" test, consisting of 1000 hours of exposure to 85°C and 85% relative humidity;
  - a "hot-spot" test, which determines a module's ability to tolerate localized shadowing (which can cause reverse-biased operation and localized heating);
  - static loading, front and back, of 2400 pascals (50 psf); front loading (e.g. snow) of 5400 pascals (113 psf).

The BP 2150L is recognized by Underwriter's Laboratories for electrical and fire safety.

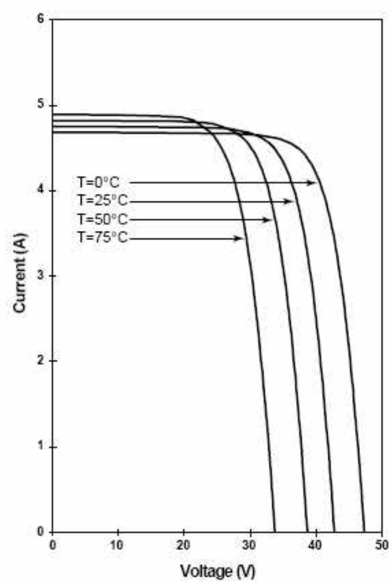
Electrical Characteristics[1]

	BP 2150	BP 2140[4]
Maximum power (P_{max})[2]	150W	140W
Voltage at P_{max} (V_{mp})	34.0V	34.0V
Current at P_{max} (I_{mp})	4.45A	4.16A
Minimum P_{max}	140W	130W
Short-circuit current (I_{sc})	4.75A	4.48A
Open-circuit voltage (V_{oc})	42.8V	42.8V
Temperature coefficient of I_{sc}	(0.065±0.015)%/°C	
Temperature coefficient of voltage	-(160±20)mV/°C	
Temperature coefficient of power	-(0.5±0.05)%/°C	
NOCT[3]	47±2°C	
Maximum series fuse rating	15A (S, L versions) 20A (U version)	
Maximum system voltage	600V (U.S. NEC rating) 1000V (TÜV Rheinland rating)	

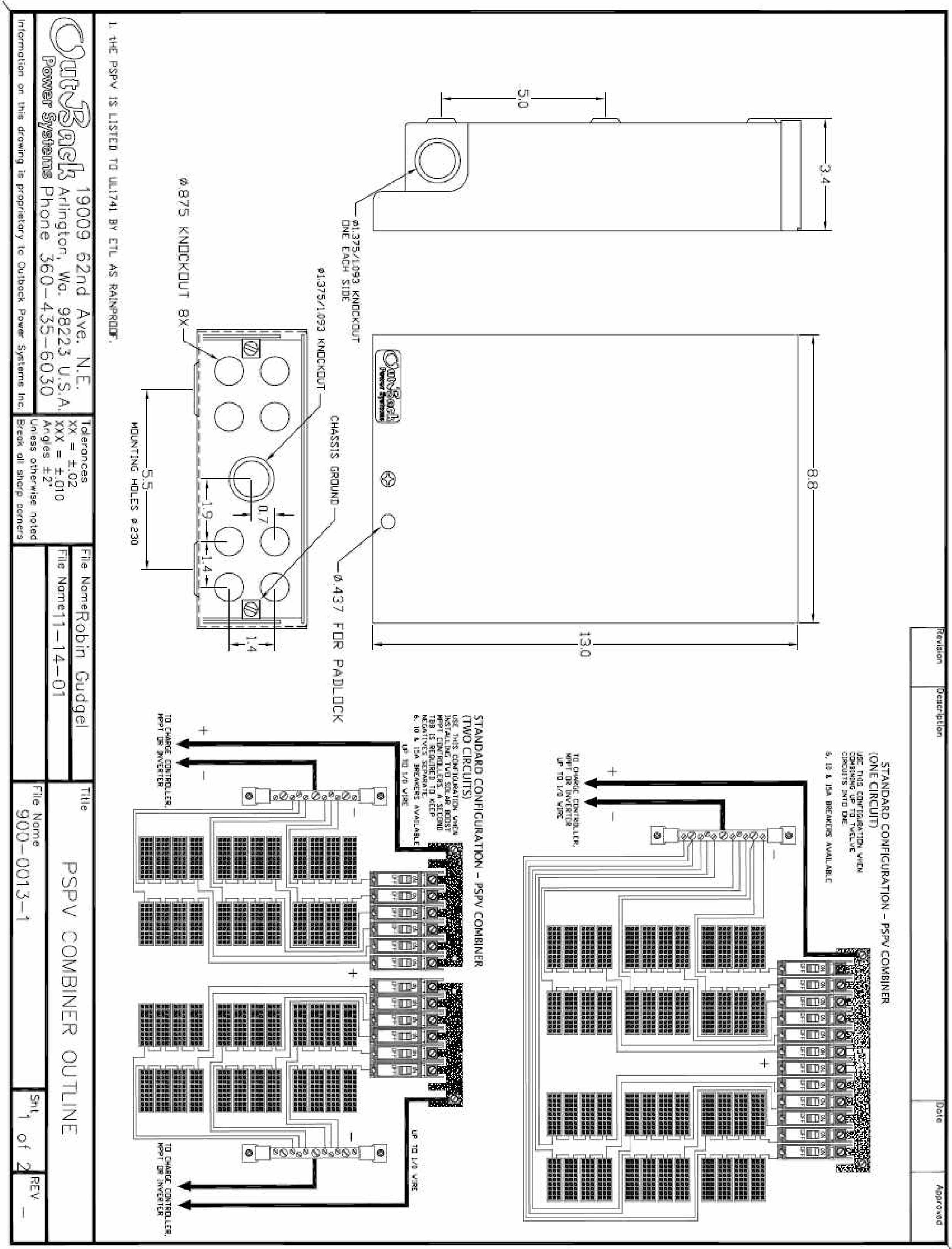
Notes

1. These data represent the performance of typical BP 2140 and BP 2150 products as measured at their output connectors. The data are based on measurements made in accordance with ASTM E1036 corrected to SRC (Standard Reporting Conditions, also known as STC or Standard Test Conditions), which are:
   - illumination of 1 kW/m² (1 sun) at spectral distribution of AM 1.5 (ASTM E892 global spectral irradiance);
   - cell temperature of 25°C.
2. During the stabilization process which occurs during the first few months of deployment, module power may decrease approximately 3% from typical P_{max}.
3. The cells in an illuminated module operate hotter than the ambient temperature. NOCT (Nominal Operating Cell Temperature) is an indicator of this temperature differential, and is the cell temperature under Standard Operating Conditions: ambient temperature of 20°C, solar irradiation of 0.8 kW/m², and wind speed of 1m/s.
4. The power of solar cells varies in the normal course of production; the BP 2140 is assembled using cells of slightly lower power than the BP 2150.

BP 2150 I-V Curves



Combiner Box

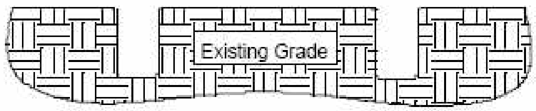


Mounting System

Ground Trac®

Ground Mount System
By: Professional Solar Products

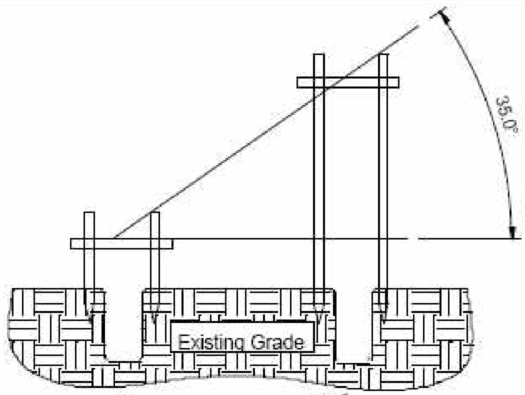
STEP #1



SIDE VIEW

Excavate footings as per detail or engineered plan

STEP #2



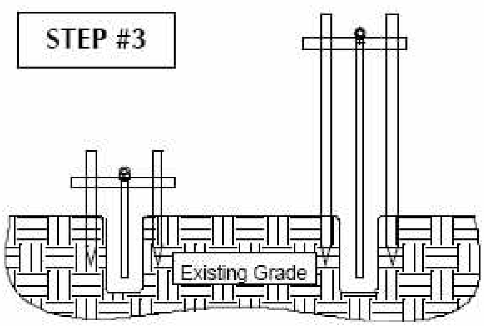
SIDE VIEW

Distance of base depends upon the angle of support channel.

Determine the proper angle for the module array and install grade stakes as illustrated (left), do not exceed 5 ft. of vertical post length from grade.

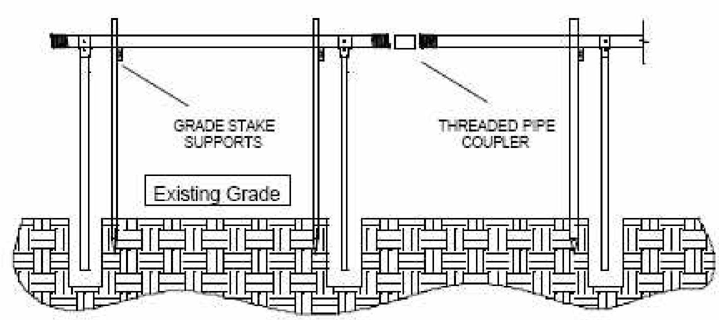
Installing the supports braces will hold the pipe at the proper fixed angle until the footings are poured. We recommend the use of drywall screws to hold the horizontal brace in place until concrete sets. Install the end braces and then set up a string line to insure alignment. Place supports at a distance that will allow the pipe beam to be supported without sagging.

STEP #3



SIDE VIEW

Illustrated (left) pipe support beams and vertical post supports can now be assembled and rest on the support bracing. Using two pipe wrenches and 3/16″ hex wrench, the pipe and support legs can be assembled and are ready for the Roof Trac™ module channel to be installed.



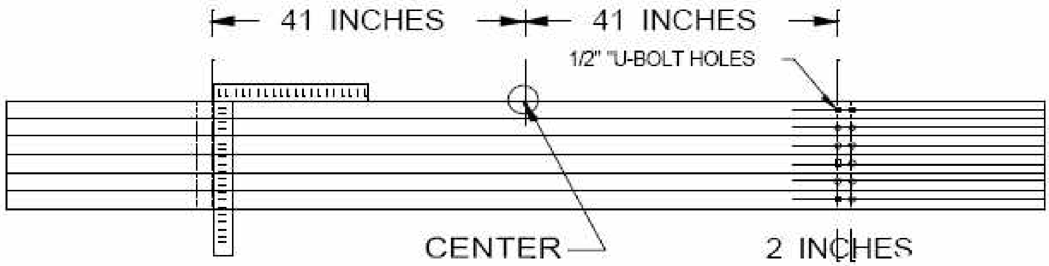
Special Note: Use only schedule #40 galvanized pipe, fence tube is not recommended

Rear view of pipe support beam bracing and

Ground Trac®

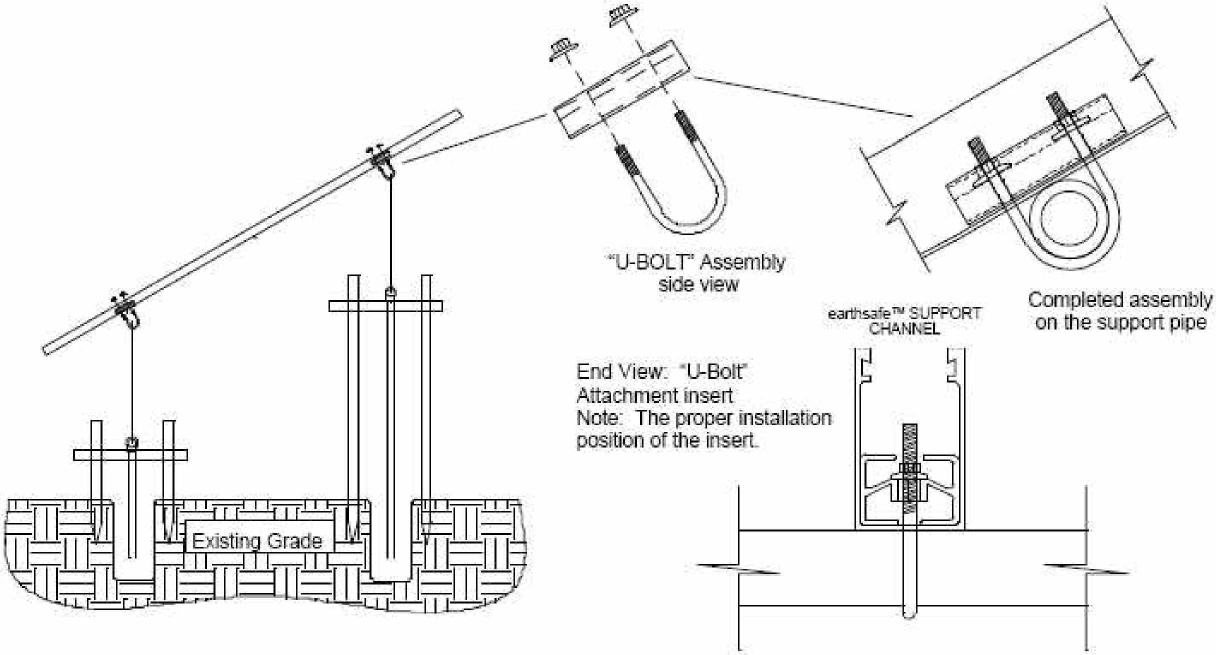
Ground Mount System
By: Professional Solar Products

STEP #4

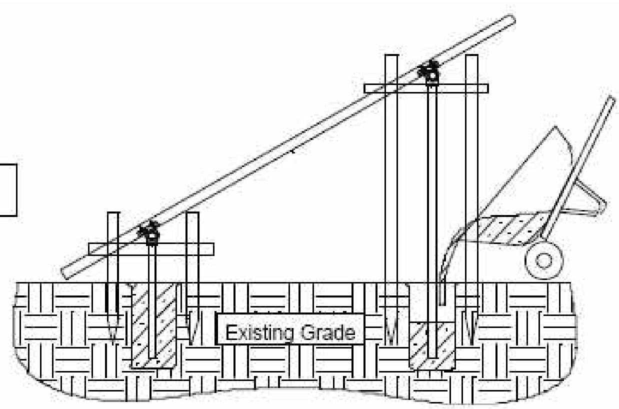


Drilling of the support channels: Align the support rails with the bottom side up on a flat surface. Using a framing square as illustrated, measure from the center of the channel 41" outward and mark a line on the channel. Mark another line exactly 2" outward from center from the first line. Now drill the "U-Bolt" holes in alignment with the marked line and the specially extruded "V" groove on the channel. We recommend the use of a 1/2" "Uni-Bit®" bit for this. You will now have perfectly aligned holes ready for installation on the support pipe beams.

STEP #5



STEP #6

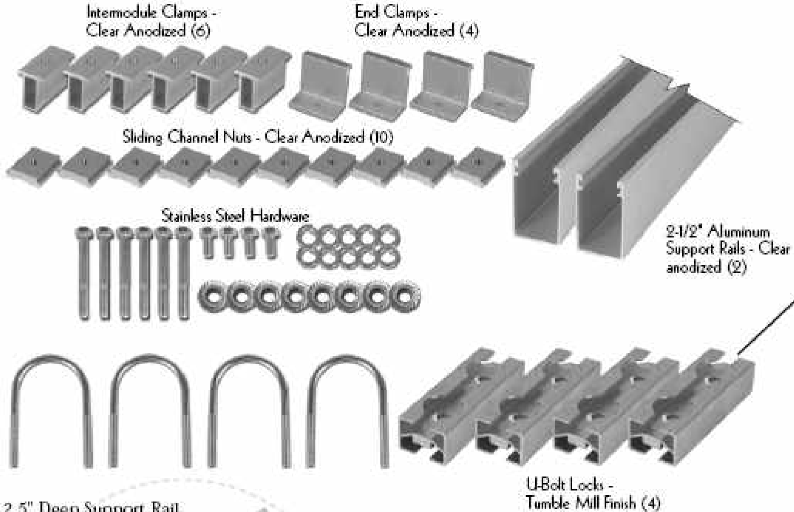


Align the end of the channel using a string line. Tighten all the "U-Bolt" assemblies and re-check alignment the vertical pipe supports. You are now ready to pour concrete into the footings. Tap the concrete to ensure contact with the vertical pipe support. Remove the support bracing after the concrete has set. You are now ready to install your modules.

CAUTION: Extruded edges of the aluminum can be sharp. It is highly recommended the installer buff the edges after installation to prevent injury.

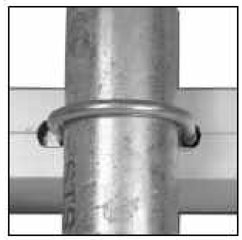
Ground Trac®

PRODUCT SPECIFICATIONS

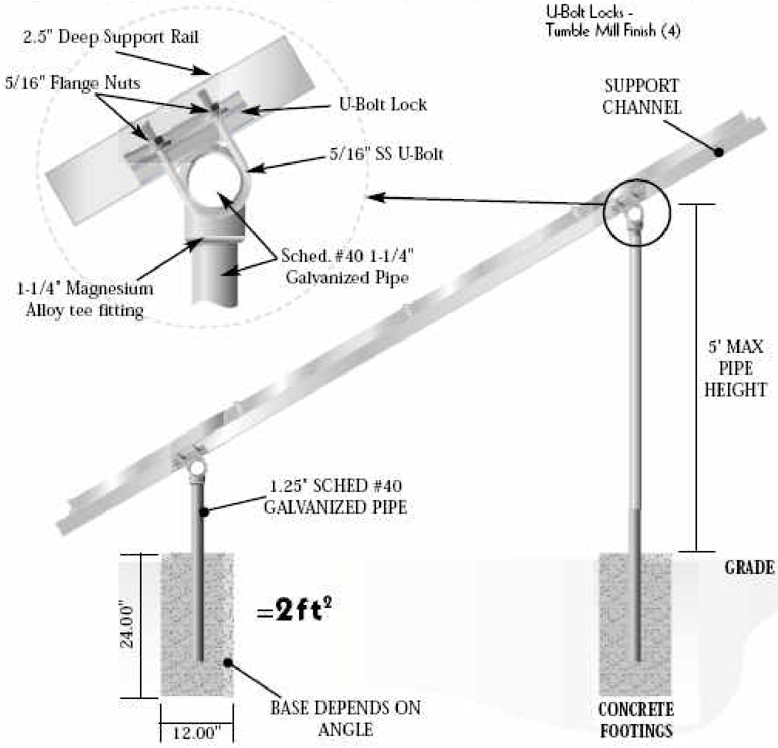


U-bolt lock is designed to push outward into the rail when fully engaged to provide a stronger, more structural system.

The design also allows for water to flow through the channel to prevent freeze damage in colder climates.



U-bolt attachment is clean and seamless - all hardware is concealed in the channel for an aesthetically pleasing array.



ENGINEERING:

System has been engineered & tested to 100mph wind load under the supervision of a California licensed structural engineer.

CAPACITY/SPECIFICATIONS:

- *Each kit supports 4 modules*
- *Specifies 1-1/4" Sched. #40 Galvanized Pipe (available at any plumbing supply)*
- *2 cu. ft. concrete footings*
- *Requires 1-1/4" Magnesium alloy tee fittings (Sold Separately from Kit)*
- *Max height 5' from grade*
- *Max canteliever 24"*
- *Max spans 10' on center (non snow load conditions)*

professional SOLAR products inc.
(800) 84-SOLAR
4630 Calle Quetzal
Camarillo, CA 93012
www.RoofTrac.com

Black Anodized clips, clamps and hardware available for select modules. All clamping hardware sizes are proprietary to the module manufacturer. Please call for details on where to purchase and availability. Support rail and Clamping system design covered under pat. #6,360,491

July 2003

Wind Turbine

AIR-X Marine Manual Document #0057 REV C

7. SPECIFICATIONS

7.1 TECHNICAL SPECIFICATIONS

Rotor Diameter:	46 inches (1.17 meters)
Weight:	13 lb. (6kg)
Start up wind speed:	7 mph (3.0 m/s)
Rated Power:	400 watts at 28 mph *(12.5 m/s)*
Regulator Set Range:	12v 13.6V – 17.0V preset to 14.1V
	24v 27.2V – 34.0V preset to 28.2V
Recommended Fuse Size:	12v - 50 amps slow-blow
	24v - 30 amps slow-blow
Yaw Wire Size:	#10 AWG *(American Wire Gage)* stranded.
Pole Dimensions:	1½ Schedule 40 pipe *(outside diameter 1.875 inch, 48mm)*

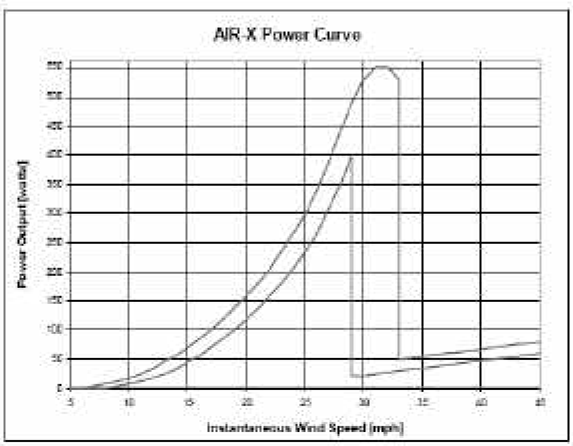
AIR-X Marine Manual Document #0057 REV C

7.2 PERFORMANCE SPECIFICATIONS

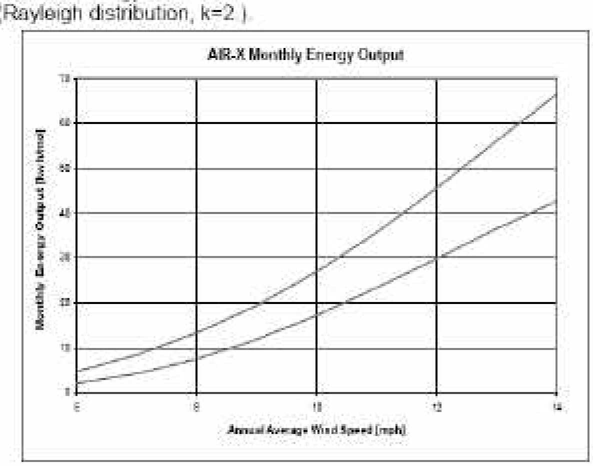
The following curve shows the performance you should expect from your ***AIR-X*** wind turbine. The ***AIR-X*** is rated with a "band-width" of power for a given wind speed. This is an attempt to cover the variability in turbine output due to different levels of wind turbulence. During smooth, steady wind, you should expect to see outputs along the upper curve. During turbulent wind conditions, the power output could drop towards the lower curve.

To convert between power [watts] and current [amps] use the following formula:

POWER = VOLTAGE * AMPS



The power curve band-width shown above gives the range of monthly energy production shown below. The energy calculations were done with standard statistical wind speed distributions (Rayleigh distribution, k=2).



Charge Controller

PV MPPT CHARGE CONTROLLER MX60

The OutBack MX60 Maximum Power Point Tracking (MPPT) charge controller enables your PV system to achieve its highest possible performance. The MPPT feature can give you up to **30% or more power** from your PV panels!

Rated for up to **60 amps** of DC output current, the OutBack MX60 can be used with battery systems from 12 to 60 vdc with PV open circuit voltage as high as **140 voc.** The MX60's setpoints are fully adjustable to allow use with virtually any battery type, chemistry and charging profile.

The OutBack MX60 allows you to use a higher output voltage PV array with a lower voltage battery - such as charging a 24 vdc battery with a 48 vdc PV array. This reduces wire size and power loss from the PV array to the battery location while maximizing the performance of your system and **saving you money**!

The OutBack MX60 comes standard with an easy to use and understand display. The four line, 80 character, backlit LCD display is used for programming and monitoring of the system's operation including built-in **Data Logging** with 64 days of memory. Daily and Total PV production in Amp hours & kWh and is user resettable.

The OutBack MX60 can also be connected to the OutBack MATE system controller and display to allow monitoring from a distant location - **up to 1000 feet (305M) away.** The MATE also includes an opto-isolated RS232 port for connection to a PC computer for system monitoring. Please see; www.RightHandEng.com/OutBack for a free PC software trial version!

SPECIFICATIONS	MX60
Output Current	60 amps DC Rated Adjustable to 70 amps Maximum
Nominal Battery Voltage	12, 24, 32, 36, 48, 54 or 60 VDC (programmable)
PV Open Circuit Voltage	140 VDC Maximum
Standby Power Consumption	1 watt typical
Charging Regulation Methods	Five Stage: Bulk, Absorption, Float, Silent, Equalization
Voltage Regulation Setpoints	13 - 80 VDC
Equalization Voltage	Up to to 5.0 VDC above Absorb Setpoint Adjustable Timer - Auto Terminate
Temperature Compensation	-5.0mV/°C/Cell
Voltage Step-Down Capability	Can charge a 12 or 24 VDC battery from a 48V nominal PV array
Power Conversion Efficiency (typical)	99% @ 50 amps Output, 48V battery and 48V array
Digital Display	4 line 80 character backlit LCD Display (30 different screens also available in **Spanish**!)
Remote Interface	RJ 45 Modular Connector CAT 5 Cable 8 wire
Operating Temperature Range	-40° to 60°C Power derated above 25°C
Environmental Rating	Indoor Type 1
Conduit Knockouts	Two 1/2" & 3/4" on the back; One 3/4" & 1" on each side; Two 3/4" & 1" on the bottom
Warranty	Two years parts and labor Optional Extended Warranty Available
Dimensions	Enclosure: 14.5 " H x 5.75" W x 5.75" D Shipping box: 17.75" H x 10" W x 7" D
Shipping Weight	12 lbs. - 5.4 kg

Specifications subject to change without notice. Please check our web site for additional specifications and application guidelines.

MX60 60 Amp MPPT Charge conntroller.....................$649.00
RTS Remote Temperature Sensor.....................$29.00

OutBack Power Systems - Arlington WA 98223 USA   Tel 360-435-6030   www.outbackpower.com

Inverter

APPENDIX A

Input Power Requirements:

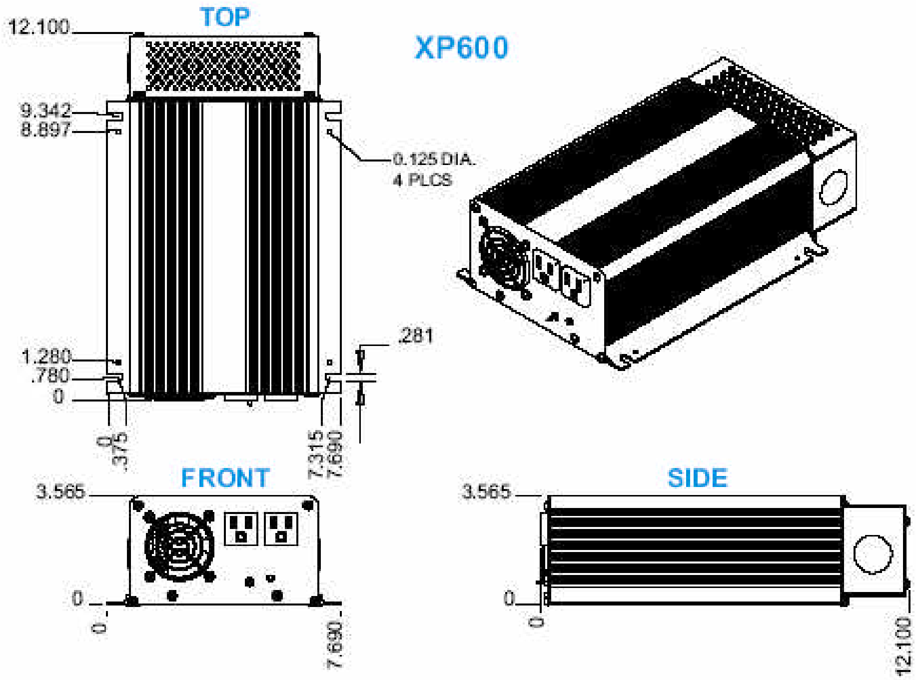
MODEL	NORMAL VDC	MINIMUM VDC CUT-OFF / ALARM	MAXIMUM VDC	RATED CURRENT	PEAK CURRENT
XP-600 / 12VDC	13.8 VDC	10.4 / 10.6 VDC	16.5 VDC	58.8 A	66.6 A
XP-600 / 24VDC	27.6 VDC	19 / 21 VDC	33 VDC	29.4 A	33.6 A
XP-600 / 48VDC	55.2 VDC	41.5 / 42.5 VDC	62 VDC	14.7 A	16.6 A
XP-600 / 66VDC	75.9 VDC	57.5 / 58.5 VDC	91 VDC	10.7 A	12.1 A
XP-600 / 108VDC	124.0 VDC	94 / 95 VDC	149 VDC	6.5 A	7.4 A
XP-1100 / 12VDC	13.8 VDC	10.4 / 10.6 VDC	16.5 VDC	107.8 A	122.1 A
XP-1100 / 24VDC	27.6 VDC	19 / 21 VDC	33 VDC	53.9 A	61.6 A
XP-1100 / 48VDC	55.2 VDC	41.5 / 42.5 VDC	62 VDC	27 A	30.5 A
XP-1100 / 66VDC	75.9 VDC	57.5 / 58.5 VDC	91 VDC	19.6 A	22.1 A
XP-1100 / 108VDC	124.0 VDC	94 / 95 VDC	149 VDC	12 A	13.6 A

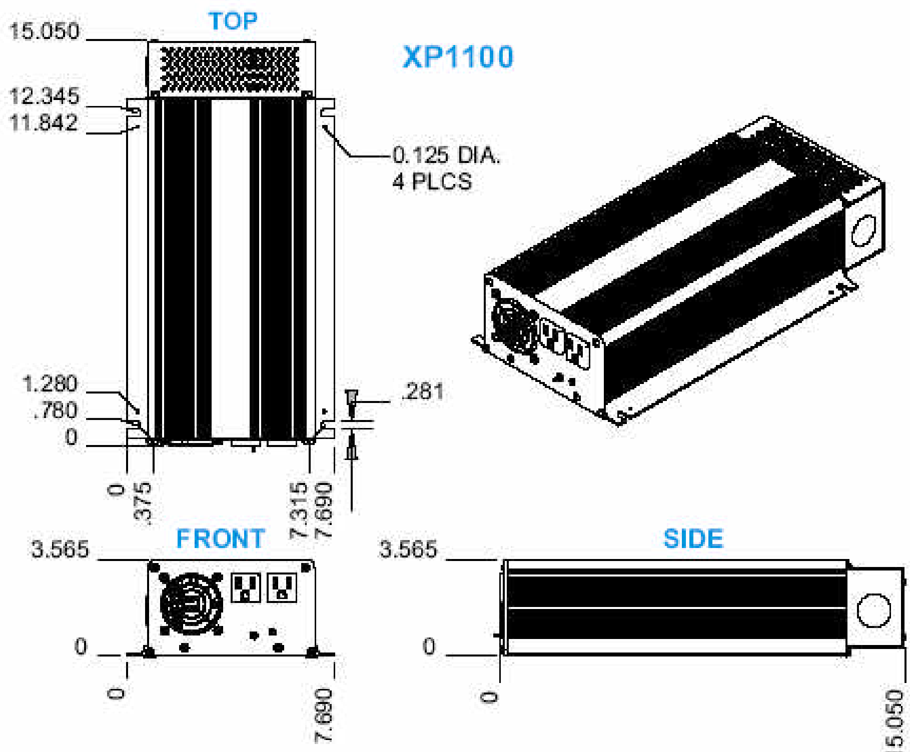
Recommended Input Wire Sizes (For Variable Distances from the Battery):

MODEL	LESS THAN 5'	LESS THAN 10'	LESS THAN 15'	LESS THAN 20'
XP-600 / 12VDC	4 AWG	0 AWG	0 AWG	00 AWG
XP-600 / 24VDC	10 AWG	6 AWG	4 AWG	4 AWG
XP-600 / 48VDC	16 AWG	12 AWG	10 AWG	10 AWG
XP-600 / 66VDC	18 AWG	16 AWG	14 AWG	12 AWG
XP-600 / 108VDC	18 AWG	18 AWG	18 AWG	16 AWG
XP-1100 / 12VDC	0 AWG	00 AWG	0000 AWG	0000 AWG
XP-1100 / 24VDC	6 AWG	4 AWG	2 AWG	0 AWG
XP-1100 / 48VDC	12 AWG	10 AWG	8 AWG	6 AWG
XP-1100 / 66VDC	16 AWG	12 AWG	10 AWG	10 AWG
XP-1100 / 108VDC	18 AWG	16 AWG	14 AWG	14 AWG

Note: The table specifies standard wire sizes (not smaller than 18 AWG) that will provide less than a 2% voltage drop at Low-line Input voltage and Rated Output Power.

APPENDIX *A*


TOP
XP600
12.100
9.342
8.897
0.125 DIA.
4 PLCS
.281
1.280
.780
0
0
.375
7.315
7.690
FRONT
3.565
0
0
7.690
SIDE
3.565
0
0
12.100


TOP
XP1100
15.050
12.345
11.842
0.125 DIA.
4 PLCS
.281
1.280
.780
0
0
.375
7.315
7.690
FRONT
3.565
0
0
7.690
SIDE
3.565
0
0
15.050

Battery Charger

DLS-Series Models	27 VOLT DLS			36 VOLT DLS†	42 VOLT DLS†	48 VOLT DLS†	
	DLS 27-15	DLS 27-25	DLS 27-40‡	DLS 36-20	DLS 42-18	DLS 48-15	DLS 48-20
DC Output Voltage (No Load) approx.	27.2 V (DC)	27.2 V (DC)	27.2 V (DC)	36V (DC)	42V (DC)	48V (DC)	48V (DC)
Output Voltage Tolerance (No Load)	+ or - .5%	+ or - .5%	+ or - .5%	+ or - .5%	+ or - .5%	+ or - .5%	+ or - .5%
Output Amperage, Max Continuous	15 Amps	25 Amps	40 Amps	20 Amps	18 Amps	15 Amps	20 Amps
Output Voltage (Full Load) approx.	>27.0V (DC)	>27.0 V (DC)	>27.0 V (DC)	>35.8V (DC)	>41.8V (DC)	>47.8V (DC)	>47.8V (DC)
Maximum Power Output, Continuous	400 Watts	675 Watts	1100 Watts	720 Watts	750 Watts	720 Watts	960 Watts
Ripple and Noise	<50 mV rms	<50 mV rms	<50 mV rms	<50 mV rms	<50 mV rms	<50 mV rms	<50 mV rms
Input Voltage Range	108 - 132 AC	108 - 132 AC	108 - 132 AC	108 - 132 AC	108 - 132 AC	108 - 132 AC	108 - 132 AC
Input Voltage Frequency	47-63	47-63	47-63	47-63	47-63	47-63	47-63
Maximum AC Current	7.0 Amps	11.6 Amps	20 Amps	11.6 Amps	12.0 Amps	11.6 Amps	15 Amps
Typical Efficiency	>80%	>80%	>80%	>80%	>80%	>80%	>80%
Max Inrush Current, Single Cycle	8 Amps	16 Amps	20 Amps	25 Amps	25 Amps	25 Amps	32 Amps
Short Circuit Protection	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Overload Protection	>100%	>100%	>100%	>100%	>100%	>100%	>100%
Line Regulation	100 mV rms	100 mV rms	100 mV rms	100 mV rms	100 mV rms	100 mV rms	100 mV rms
Load Regulation	<1%	<1%	<1%	<1%	<1%	<1%	<1%
Fan Control*	PROPORTIONAL	PROPORTIONAL	PROPORTIONAL	PROPORTIONAL	PROPORTIONAL	PROPORTIONAL	PROPORTIONAL
Thermal Protection	YES	YES	YES	YES	YES	YES	YES
Working Temperature Range	0 - 40C	0 - 40C	0 - 40C	0 - 40C	0 - 40C	0 - 40C	0 - 40C
Storage Temperature	-20 to 80C	-20 to 80C	-20 to 80C	-20 to 80C	-20 to 80C	-20 to 80C	-20 to 80C
Withstand Voltage	1240V @ leads	1240V @ leads	1240V @ leads	1240V @ leads	1240V @ leads	1240V @ leads	1240V @ leads
Dimensions**	7" x 6.5" x 3.5"		10" x 6.5" x 3.5"	7" x 6.5" x 3.5"	7" x 6.5" x 3.5"	7" x 6.5" x 3.5"	10" x 6.5" x 3.5"
Weight	5.5 lbs	5.5 lbs	7.8 lbs	5.5 lbs	5.5 lbs	5.5 lbs	7.8 lbs

* Proportional = Fan speed proportional to case temperature

**Detailed Mounting Specifications are available online.

† Units are not UL Listed

‡ Can be used as 24V 50 Amp unit

P.O. BOX 11846 TUCSON, AZ 85734 • 1301 E. WIEDING ROAD TUCSON, AZ 85706 • (520) 294-3292 • FAX (520) 741-2837

www.iotaengineering.com

IOTA ENGINEERING, L.L.C.

Enclosure

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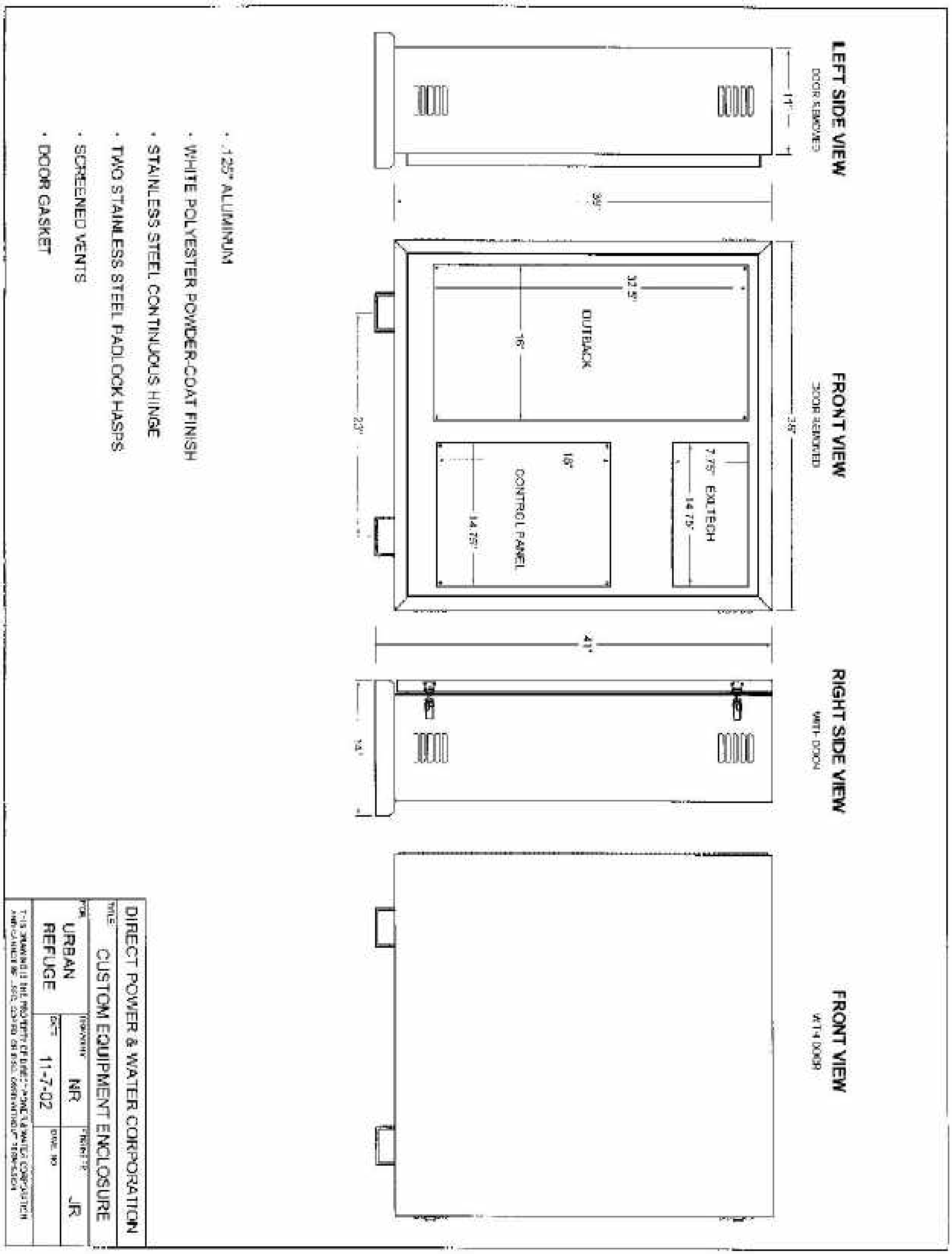


Outback PSDC

OutBack Power Systems

PSDC

POWER SYSTEM DC

OutBack Power Systems has developed a new solution for all of the DC components of a renewable energy power conversion system.

The **PSDC** saves time, money and space by combining the disconnects, overcurrent protection devices, grounding and control components into an easy to install, single enclosure.

The **PSDC** is easily modified and expanded as your system grows or changes.

Standard Features and Components

- ETL listed indoor type powdercoated steel enclosure with plenty of conduit knockouts
- Mounting space for up to four large 1.5" wide 175 or 250 amp or six medium 1.0" wide 60 to 100 amp breakers – sizes can be mixed
- Ten spaces for small 0.75" wide 15, 30 or 60 amp breakers and **OBDC-GFP/2** (uses 3 spaces)
- 500 amp 50 mV current shunt standard
- Battery negative/ground bus bar standard
- Battery positive bus bar for DC loads and PV arrays included standard
- Designed to mount directly to the DC end of 1 or 2 Trace DR or SW series inverters without needing additional conduit boxes or fittings
- Easily connected to other inverter models and enclosures via conduit or raceway
- Knockouts on top for two RVPP Solar Boost or three C-series controllers
- Available with or without the circuit breakers and other options pre-installed
- For negative or positive ground systems

Finally

an

alternative

to

Brand

X

Optional Components

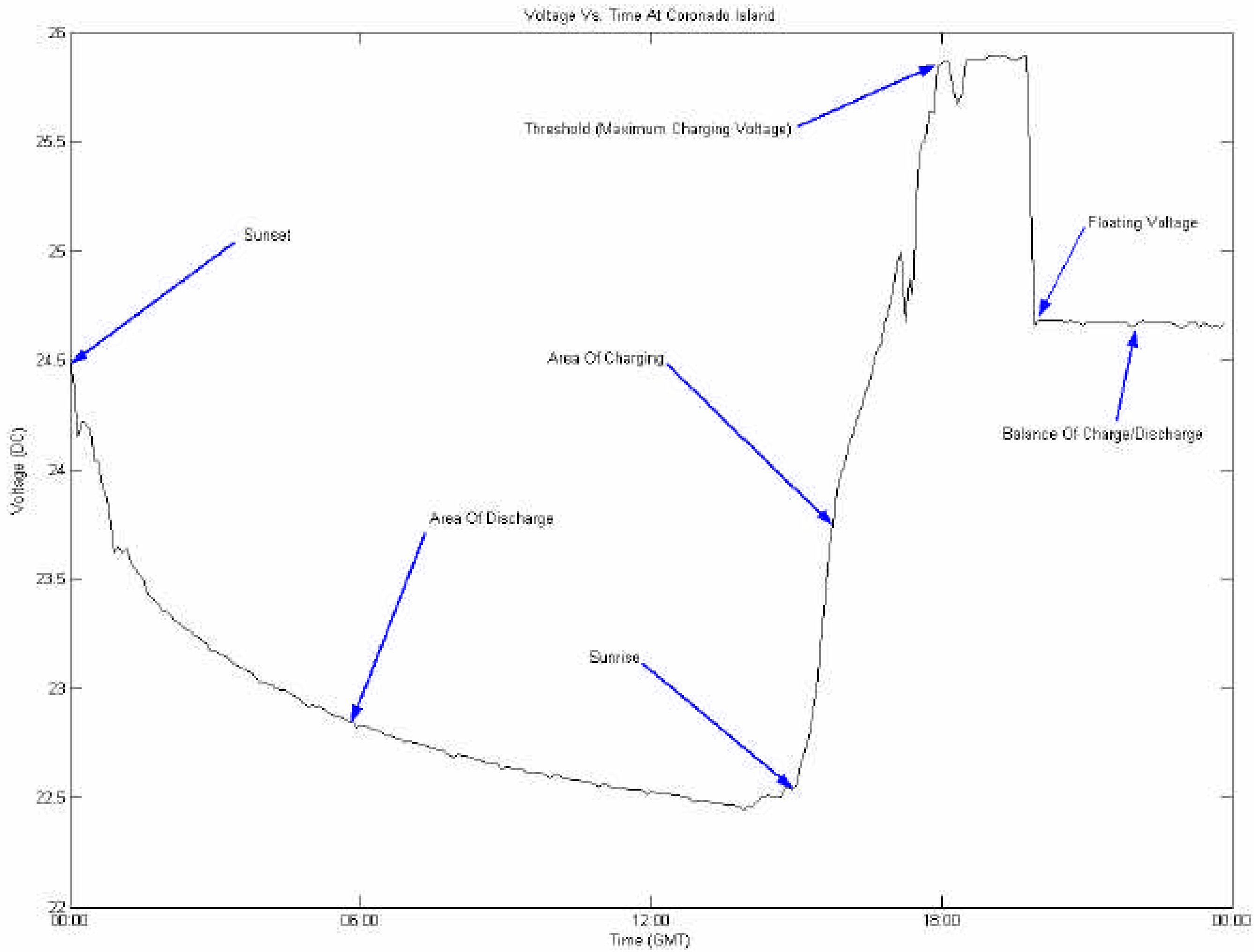
- **15, 30, 60, 100, 175 & 250 amp DC rated breakers** for DC inputs/loads and power inverters
- **OBDC-GFP/2** - Dual 60 amp PV ground fault protection system for two PV charge controller. Multiple DC-GFP/2 can be used on the same system – up to four can be installed in a PSDC
- **CCB** - Charge controller bracket for up to three additional C-series controllers on either side
- **TBB** – Insulated terminal bus bar kit for combining or distributing multiple circuits
- **GBB** - Ground bus bar kit for isolating the negative from ground (included with GFP/2 system).
- **VREA** - Adapter plates for direct connection of a PSDC to one Vanner RE inverter/charger
- **PSA** – Adapter plate for direct connection of a PSDC to one PS series inverter/charger
- **MP** - Mounting Plate for assembling a complete power system – 36" wide x 50" wide x 1" thick - for one PSDC, one PSAC and one or two inverter/chargers – split design to allow UPS shipping

Physical Dimensions

- **PSDC** enclosure: 16" wide x 9" deep x 32.5" tall (40.6cm x 22.8cm x 82.5cm)
- Shipping size: 12.75" x 36" x 19.5" Weight: 38 pounds (17.3 kG) + options

OutBack Power Systems, Inc. Tel 360.435.6030 Fax 360.435.6019
19009 62nd Ave NE, Arlington, WA 98223 USA www.outbackpower.com

7. Performance Information



8. Additional Photos