Remote Solar Power and Data Acquisition System

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Intro/Purpose

The function of this system – RSPDAS (Rasp•ah•das) –is to provide power to an isolated array of instruments without the dependence of active maintenance. It is intended to power an array of radio antennae and other accompanying hardware. It will be placed in either western Australia (Murchison Radio Observatory) or Christmas Island.

Brief Introduction

This system's primary functions include powering a small array of antenna, replacing the diesel generator, and remotely monitor and control the various parameters tracking the system.

Figure 1 – Current diesel generator at the EDGES-DARE site.

Major components:

- Solar panels (2X)
- Dock box
- MPPT-CC (Maximum Power Point Tracking Charge Controller)
- 12V/110Ah Lead-acid Batteries (6X)
- ATX M4 Board
- RFI Cage
- Pass-through filters (4X)
- PC (Linux)

An extensive description of each individual component will be provided in the following section.

Component Characterization

Solar Panels

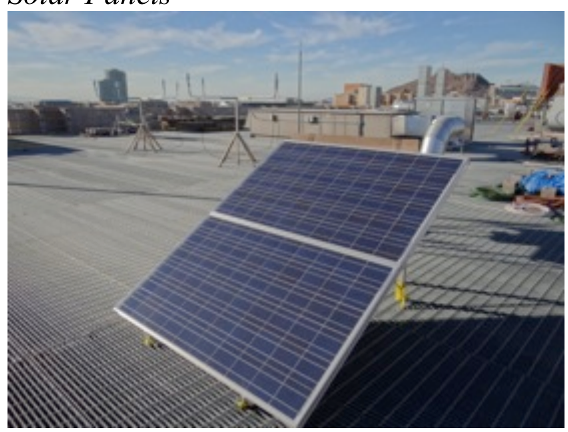

Figure 2

There are four photovoltaic panels used for this system. They are manufactured by Sharp and are high powered (224W) using 156mm square polycrystalline silicon solar cells with 13.7% module conversion efficiency [1]. Some specifications are shown in the next page.

Panels are arranged in two sets of two. This is because we have two rail stands that are design to hold two panels each (as shown in the figure above). The assembly of these stands was reconfigured to fit our needs – the exact manual was not followed as it was found to be imprecise along with missing various parts. [2]

ELECTRICAL CHARACTERISTICS	
Cell	Poly-crystalline silicon
No. of Cells and Connections	60 in series
Open Circuit Voltage (Voc)	36.6V
Maximum Power Voltage (Vpm)	29.28V
Short Circuit Current (Isc)	8.33A
Maximum Power Current (Ipm)	7.66A
Rated Power (Pm)*	224W (+10% / -5%)
Module Efficiency	13.74%
Maximum System Voltage	600V
Series Fuse Rating	15A
Type of Output Terminal	Lead Wire with MC Connector

Figure 3

MECHANICAL CHARACTERISTICS	
Dimensions (A x B x C below)	39.1" x 64.6" x 1.8" (994mm x 1640mm x 46mm)
Weight	44 lbs / 20 kg
Size of Carton	65.16" x 39.76" x 4.25" (1655mm x 1010mm x 108mm)
Carton Quantity	2 pcs per carton
Pallet Quantity	30 pcs per pallet

ABSOLUTE MAXIMUM RATINGS	
Operating Temperature (min to max, °F/°C)	-40 to 194°F / -40 to +90°C
Storage Temperature (min to max, °F/°C)	-40 to 194°F / -40 to +90°C

Figure 5

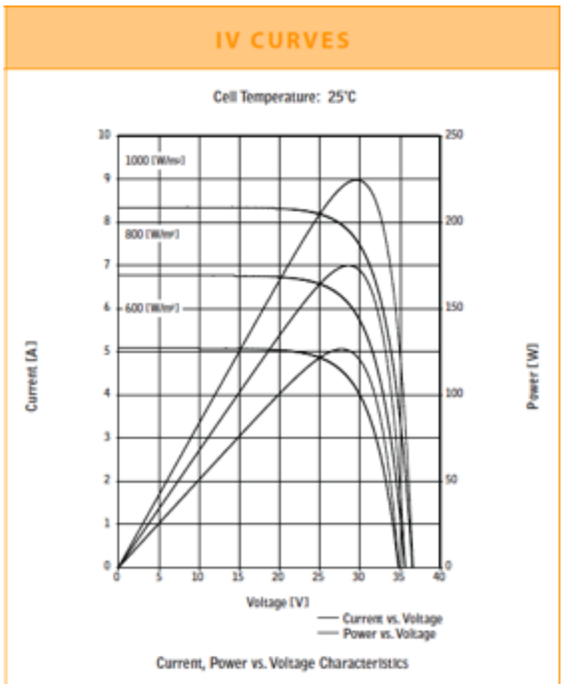

Figure 4

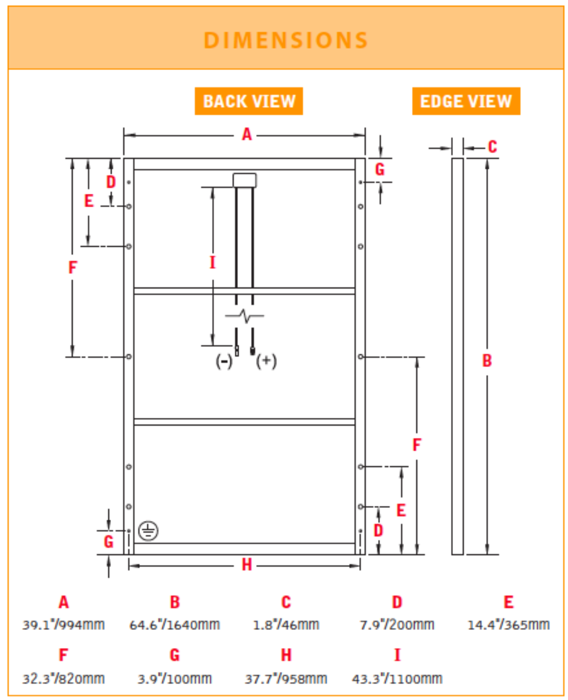

Figure 6

Dock Box

Figure 7

Dock boxes are generally designed to lodge boat supplies in marinas. It is made from heavy-duty white fiberglass with an average of 3/16" thickness and maximum dimensions, because of its trapezoidal shape, of 24"(*l*) by 42½ "(*w*) by 26¼"(*h*). This type of material and assembly also reinforces the box to not disfigure, deform or discolor over time. It is designed to resist the harshest of weather conditions. Additionally, it has a UV gel coat, which provides protection for long-term sun exposure. While it is *weatherproof* it is not waterproof - the deployment team should make sure that it is positioned in a way to avoid condensation from falling onto the top of the uncovered box or through the side vents. This box will rest on top of an industrial dolly, providing support and portability. As of now, the plan is to manually carry the box from the landing point to the final deployment location. [3]

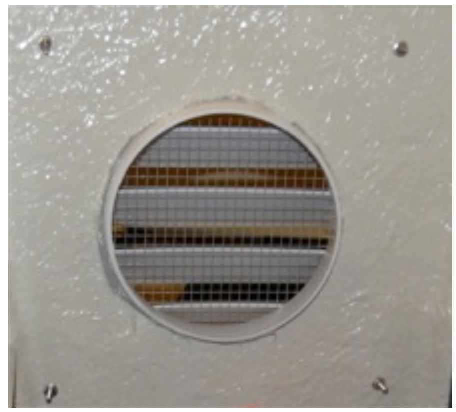

Figure 8

Two perforations were made on the left and right side of the dock box with the diameter of approximately 5.75". The perforations are covered by vents attached by silicone caulk. Vent blinds are downward facing, to avoid water inside the box, and are internally covered by a loose mesh (to prevent any unwanted critters from going inside this system).

Additionally, a CAD drawing was drafted prior to any changes or additions to

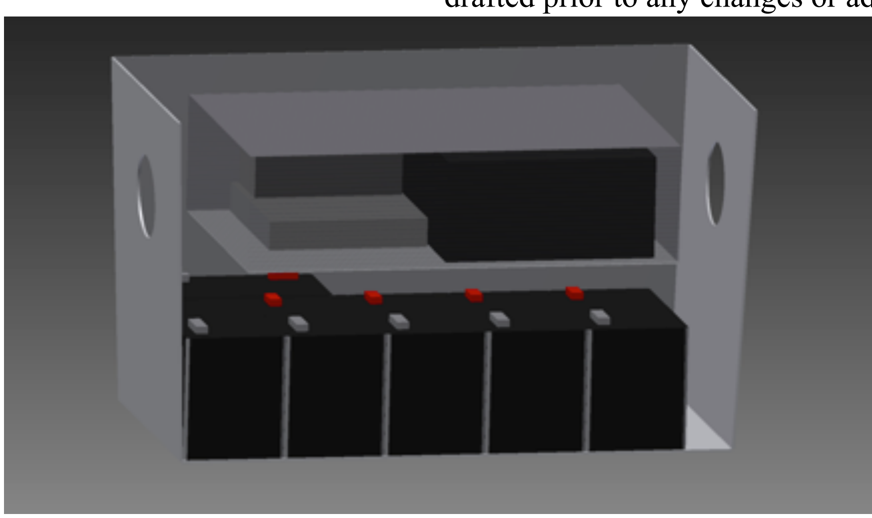

Figure 9

the box. This was not critical to the project, but it was a useful referencing tool for future augmentations to the system.

Maximum power point tracking charge controller

The MPPT-CC's functions are to monitor various parameters of the system (current, voltage, temperature, etc.) and provide safe and efficient electrical networking between all the components [4].

Figure 10 – Maximum power point tracking charge controller

Batteries

The 12V Batteries are sealed lead-acid, 110Ah, and weigh around 65 lbs each. The purpose of these will be power the system, and to provide back up power at night or when the weather conditions are unfavorable [5].

Figure 11

M4 ATX Board

In order to provide power to the PC, the DC +/- connection has to be converted to the 24-pin connection required for

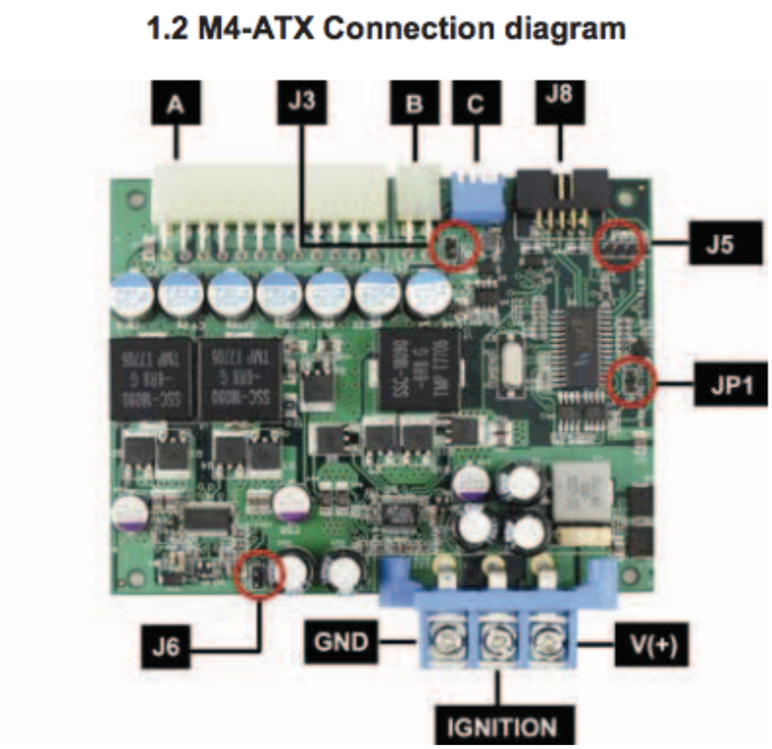

Figure 12

motherboards. This task is performed by the M4 ATX board. The board is simply a power sequencer that regulates the power from the battery to the PC's motherboard. The board's inputs are V+, ground, and ignition. Outputs are power output connector (24-pin), 12V-ATX power output connecter (4-pin), dip switches, and a USB connection. The last connection was soldered to a common USB cable. [6]

RFI (Radio-frequency interference) Cage

A large requirement of this system is to not produce any RFI interference from its components. In order to protect against from any signal leakage, most of the components (except the batteries), are securely stored inside an aluminum box.

The cage for this system was made out of lightweight alloy 3003 perforated aluminum. Three sheets were purchased – 36"x40", 0.25% hole diameter, 40% open area, and .063" thick. It was designed and constructed entirely in-house. The fabricated cage sits on top of two parallel L-channels are bolted to the sides of the dock box.

Additionally, four feed-through power filters [7] were enclosed on one side of the RFI Cage. This was done in order connect the power cables from the solar panels and batteries to the MPPT-CC inside the cage. Specifically, these filters attenuate any RF signals from the equipment and the power line outside.

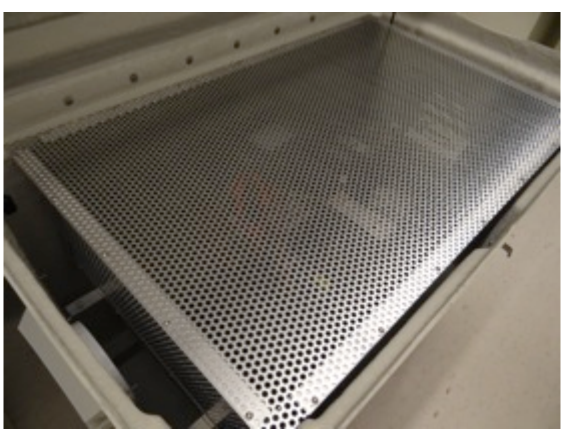

Figure 13 – RFI cage placed in dock box

Figure 14 – Feed through power filters

System Software

PC Specifications:

```
jose@solar:~$ uname --all
Linux solar 2.6.38-8-generic #42-
Ubuntu SMP Mon Apr 11 03:31:24 UTC
2011 x86_64 x86_64 x86_64 GNU/Linux
```

Titled "solar", the system PC runs Linux on an Intel i5 quad-core processor. It has an ASUS motherboard.

The MPPT-CC manufacturer has provided software to monitor the system but proved to have limited capabilities and exclusively runs of Windows [8]. Since our system operates on Linux, we had to develop a custom program using MATLAB.

Morningstar's hardware uses a medium called Modbus protocol to communicate between the charge controller and the computer. This proved rather challenging but the team used an open-source, C-code library for Linux [9] to aide in the development. With this on hand, a short C-program was developed which fed into a larger MATLAB program.

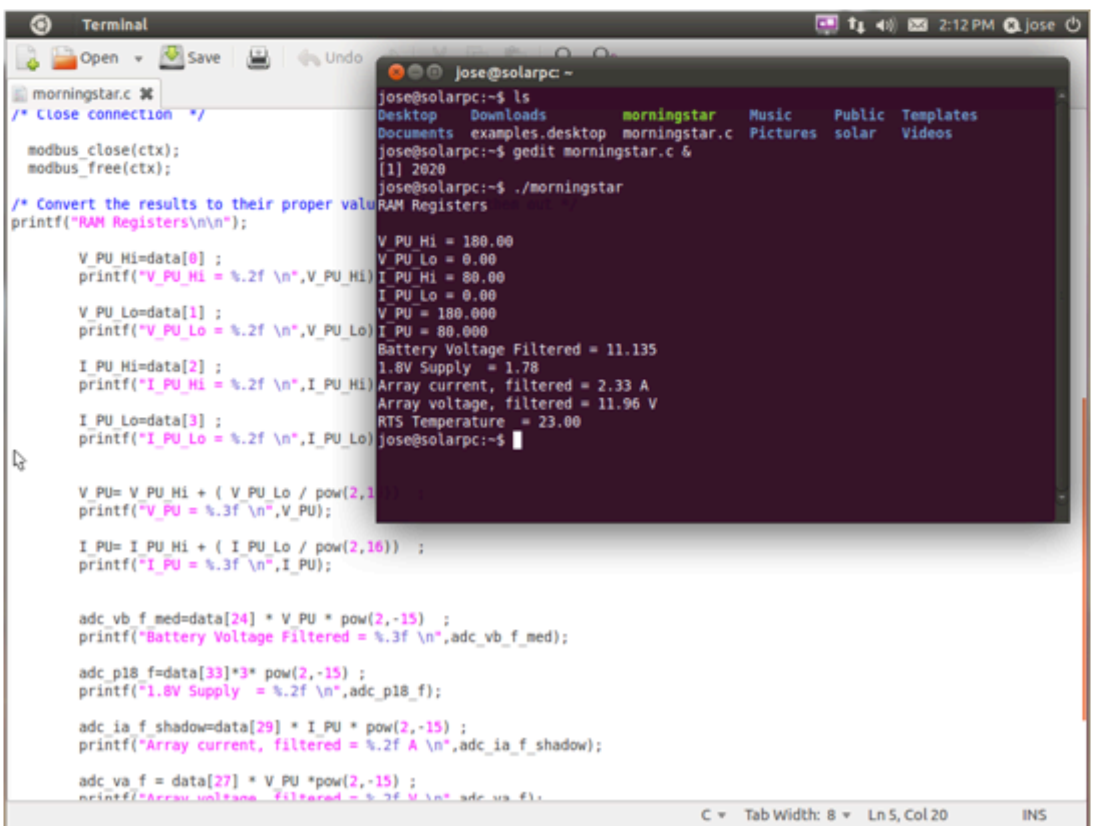

Figure 15

From startup, multiple programs record and plot the battery terminal voltage, array current, and battery temperature. The plotting utility has a slight delay but it only amounts to a few seconds after a couple of days. We might not use the plotting feature once the system is deployed as it is not required to monitor or store parameter data.

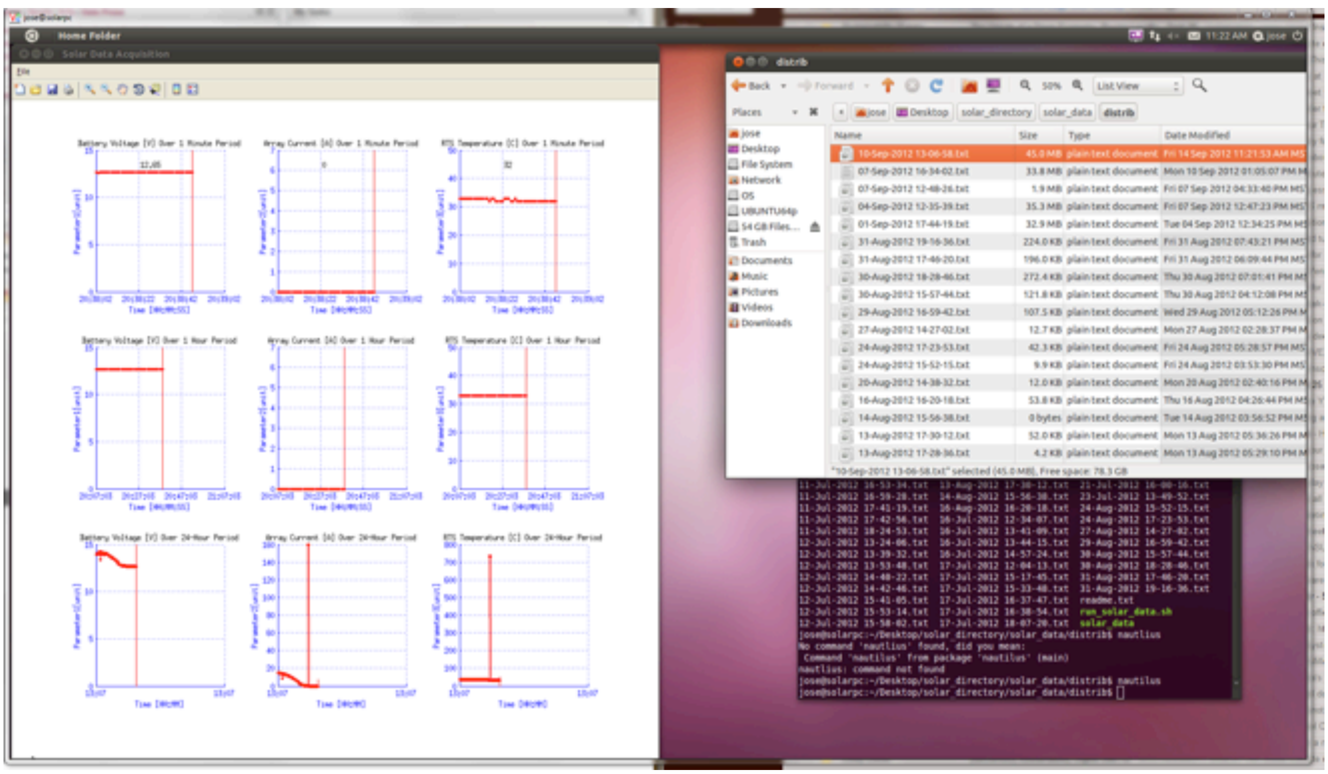

Figure 16 – The startup display.

References

1. PV Panel Data Sheet: http://www.mnsolarwind.com/224W%20ND-224u1f.pdf

2. IronRidge Rail System: http://www.wholesalesolar.com/pdf.folder/mount%20pdf%20folder/IronridgeXRS_Rail_System.pdf

3. General Info on Dock Boxes: http://www.boatliftwarehouse.com/docks/dock_boxes/large_dock_box_426.php

4. Maximum Power Point Tracking Charge Controller Specifications: http://www.morningstarcorp.com/en/tristar%20mppt

5. Battery Specification Sheet: http://upgi.com/Themes/leanandgreen/images/UPG/ProductDownloads/D5751.pdf

6. M4-ATX Manual: http://resources.mini-box.com/online/PWR-M4-ATX/PWR-M4-ATX-manual.pdf

7. Power filter datasheet: http://www.syfer.com/category_docs/SLGNC4000205M11.pdf

8. MSView software information: http://www.morningstarcorp.com/en/support/results.cfm?LibraryId=3

9. Modbus open-source library: http://libmodbus.org/