RV Solar 101

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2020

Should I invest in Solar?

Purpose of Solar

- Charge one or more batteries with power from the sun
- Minimize or eliminate generator noise and fuel consumption for charging batteries
- Keep batteries maintained while in storage

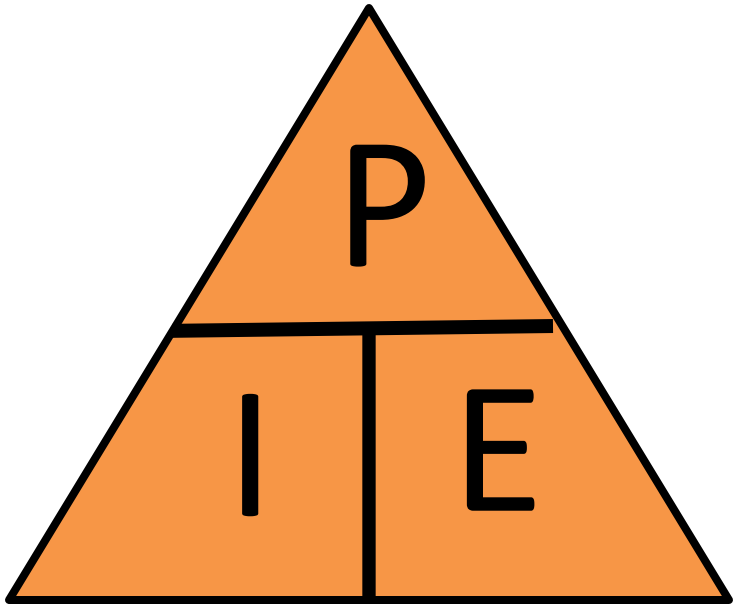
How Do I get Started?

- What type of battery bank do I need?
- How do I determine the daily consumption from my batteries?
- Will I be using an Inverter? If so, what kind and how do I hook it up?
- How much solar power do I need to recharge my batteries?
- What kind of equipment do I need?
- Portable panels or roof mounted?
  - How do I get the wires from the roof to the batteries?
- Where can I turn to for help?

Basic Electronics

- P=IE
- Power = Current x Voltage

Power (P): Watts
Current (I): Amps
Voltage (E): Volts



Step 1 – Power Requirements

How much Battery Power do I need?

How Much Battery Power Do I Need?

12 Volt System	
Aisle Lights	1.0 amps
Baggage Compartment Lights	1.4 amps
Decorative Wall Lights	1.5 amps
Dinette Light	4.5 amps
Exterior Entertainment Center	5-7 amps
Fantastic Fan	1.5 amps
Fluorescent Double Lights - 12"	2.0 amps
Fluorescent Double Lights - 18"	2.5 amps
Furnace	12.0 amps
Generator Start	95.0 amps *
Halogen Light	1.7 amps
Illuminated Switch	.125 amps
Inverter	*Variable*
Leveling System	95.0 amps *
LP Detector	.125 amps
Map Light	1.5 amps
Porch Light	1.5 amps
Power Awning	10.0 amps
Power Vent	5.0 amps
Refrigerator	3.0 amps
Shower Light	1.4 amps
Step Cover	10.0 amps
TV Plate / Antenna Booster	1.0 amps
Vanity Light	4.2 amps
Water Heater	6.0 amps
Water Pump	7.0 amps
	* Momentary load

120 Volt System	
Air Conditioner	18 amps
Coffee Maker	6-12 amps
Converter (Each)	8 amps
Curling Iron or Hair Dryer	10-14 amps
Blu-Ray/DVD System	3 amps
Microwave	12 amps
Refrigerator	6 amps
Satellite Receiver	2 amps
TV	2-4 amps
Vacuum Cleaner	8 amps
Washer / Dryer	12 amps
Water Heater	12 amps

When running 120V devices from an inverter you are drawing 10 times the current from your batteries. So a 3-amp television will be pulling 30Amps from your batteries every hour! A single 100Ah Lithium battery could be depleted in about 3 hours!

Source: GDRV Reflection TT Owners Manual

Battery Monitor
A Better Way To Determine Your Needs

Monitor Display

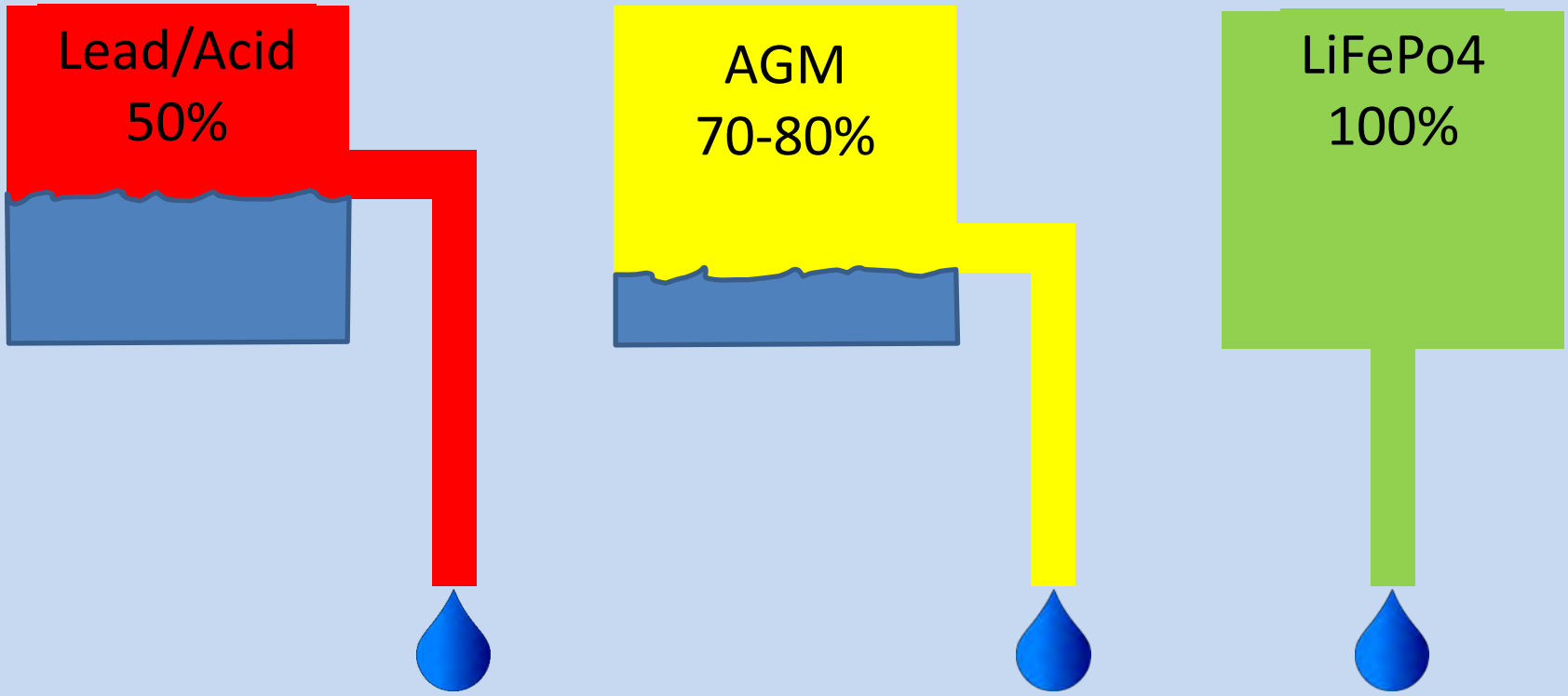
Shunt Installed in 2017
297RSTS Reflection TT

Battery Monitor
My Data

Step 2 – Power Requirements

What type and How many batteries do I need for power?
How do I install them?

Step 2 – Power Capacity



Picture a battery as a fuel tank. The type of battery is analogous to where the discharge pipe is located. You can only tap so much power from each type of battery.

Lead Acid Batteries

- Very Low Cost – Approximately $90-$120 each.
- You should only use 50% of the battery's capacity.
- A 88 Ah lead/acid battery will provide 44 Ah of useable power.
- Heavy – A 12V RV/Marine battery weights approximately 51 pounds (group 27)
- Typically have a 12 month warranty.
- Can leak. Must be vented. Maintenance required.

VOLTAGE	≃ CHARGE STATE	
>12.6	100	Note that these voltages are approximate and are influenced by temperature etc. Batteries just taken off charge will have a significantly higher voltage until the 'surface charge decays over 30mins or so.
12.5	90	
12.4	80	
12.3	70	
12.2	60	
12.1	50	
11.9	40	Repeated discharge to these levels will shorten battery life
11.8	30	
11.6	20	
11.3	10	Permanent Damage will occur
10.5	0	

Absorbent Glass Mat (AGM) Batteries

- Higher initial cost vs. lead acid. $250-$350 each.
- A 100 amp hour AGM battery will provide 60-80 amp hours of useable power.
- Spill proof. Rarely vents hydrogen gas.
- 70 pounds (Group 27)
- Warranted for 1-2 years.
- Maintenance Free

AGM BATTERY STATE OF CHARGE	
Level	Voltage
100%	13.00V
90%	12.75V
80%	12.50V
70%	12.30V
60%	12.15V
50%	12.05V
40%	11.95V
30%	11.81V
20%	11.66V
10%	11.51V
0%	10.50V

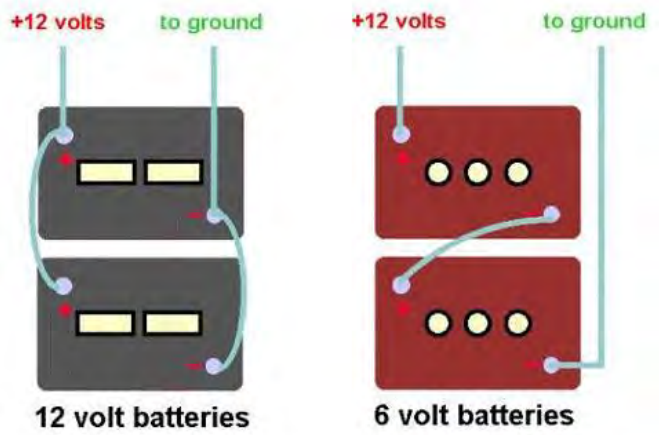
Lithium Iron Phosphate (LiFePo4) Batteries

- Highest Initial Cost ($900-$950)
- Very safe. No venting required.
- A 100-amp hour LiFePo4 battery will provide 98-102Ah of useable power.
- 3000-5000 full cycles – ten-year warranty (Battle Born)
- 29 pounds
- Maintenance Free
- Internal Battery Monitoring System
- Charges very fast – Approximately 50% of the time of lead/acid or AGM

Six Volt vs. 12 Volt Battery Banks

- 6 Volts
  - Requires batteries to be installed in pairs
  - Connect in series – Voltage increases, current capacity unchanged.
  - Primary benefit – Deep cycle golf cart style batteries typically have higher current capacity (measured in amp hours (Ah) than 12V)
  - Drawbacks – Very heavy

- 12 Volts
  - Connect in parallel – current increases, voltage unchanged.
  - Primary benefit – If one battery fails, it can be taken out of the bank.
  - Drawbacks – An equal number of 12V batteries typically have less current capacity when compared to 6V batteries.



Step 3 – Solar Charging

Now that I've built my battery bank, how Much solar power do I need to charge it?

How Much Solar Charging Do I Need?

- The primary purpose of solar charging is to bring batteries up to a fully charged state.
- Number of panels depends on:
  - Solar angle of incidence (panels flat or tilt mounted)
  - How many hours of daylight.
  - Cloud cover
  - Tree shading
  - Panel construction – bypass diodes?
  - Latitude

Rule of Thumb
One 100-Watt panel will provide 30 amps of charging per day

Using the “rule of thumb”, my needs are 149aH/30 = 5 (100-Watt) panels.

Diagram of a Basic Solar Charging System

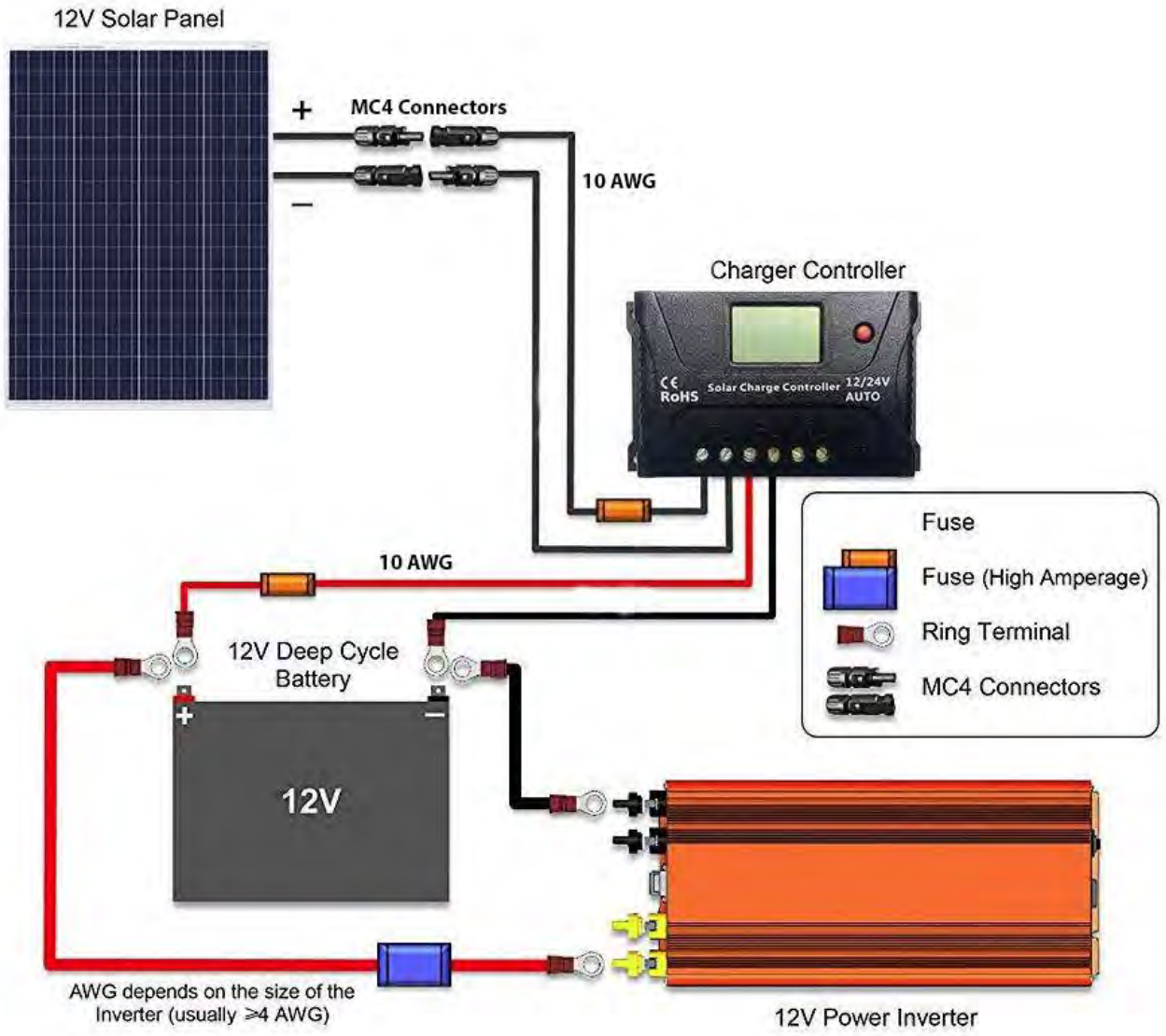
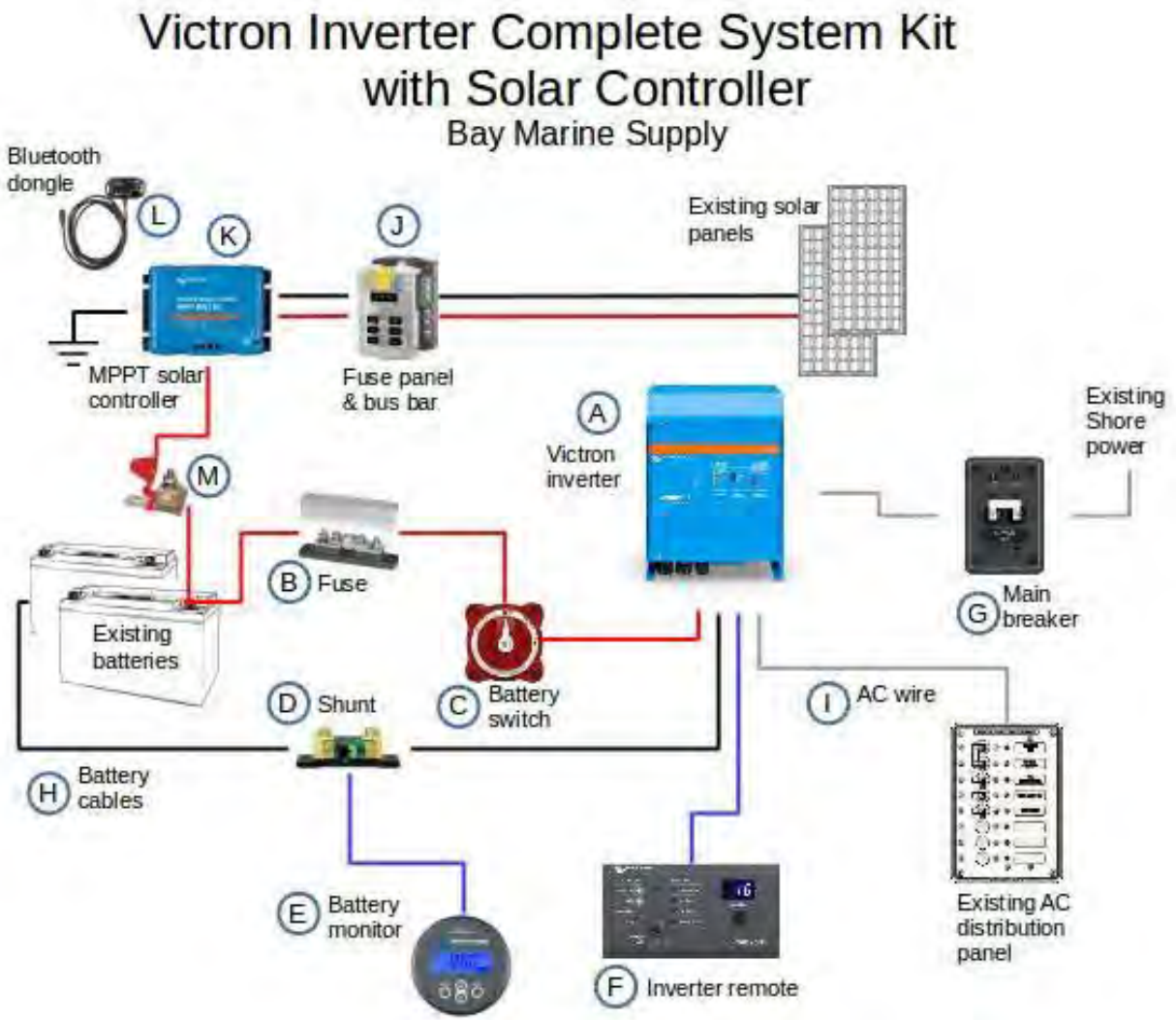


Diagram of a More Complex System



Step 4 – Installation

How do I install my solar powered Battery charging system?

Panel Mounting

Grand Design uses a 3/8” plywood roofing material. Panel brackets can be screwed through the roofing material and into the plywood for a secure mount.
Be sure to seal any roof penetrations.

Tiltable Panel Mounts
Helpful in Winter
Can be raised for cleaning the roof.

Panel Z Brackets

Panel Mounting

Tiltable Panel Mounts
Helpful in Winter
Can be raised for cleaning the roof.

Home Made Brackets

Series or Parallel

Series Connection – High voltage, low current

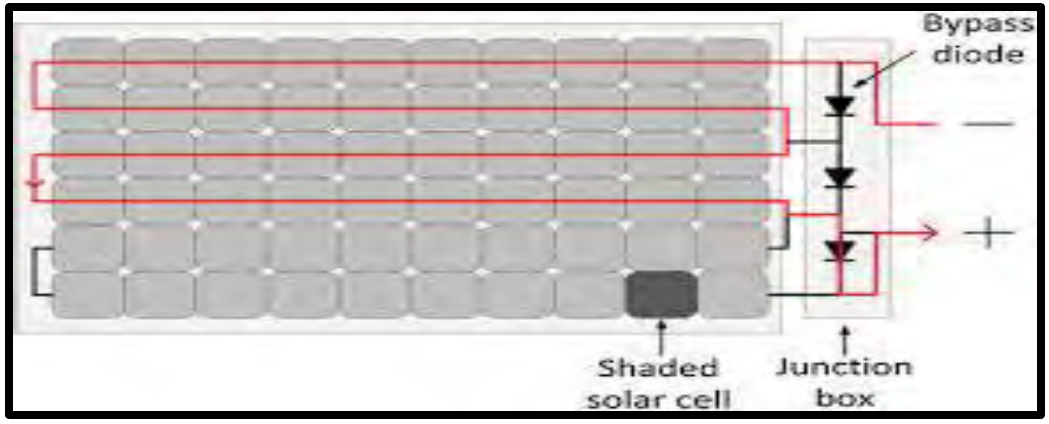
Primary Benefit: Since the current is low, and the voltage is high, smaller wires can be used. Typical wiring is 10ga solar wire with MC4 connectors.

Main Drawback: Any shading or panel failure can result in shut down of the array! (Solution: Bypass diodes)

Parallel Connection – High Current, Low voltage

Primary Benefit: Shaded panels will not shut down the array.

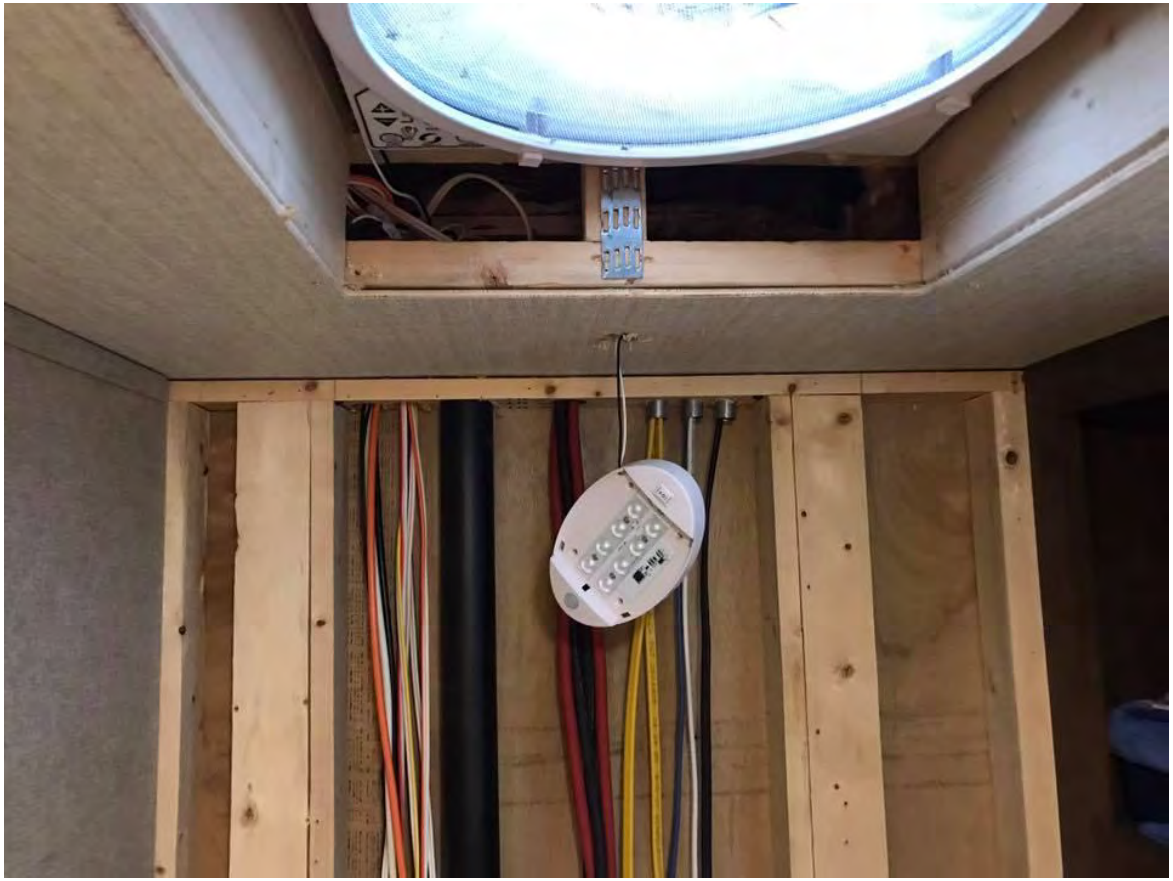
Main Drawback: Larger wire sizes.



Roof Penetration

- Some Grand Design models have a wire passageway for solar wiring.
- Grand Design runs many 120V and 12V wires in the roof. Drilling through the roof may cut wires. Use extreme caution.
- Some owners have run their wiring through vent pipes. This method will work, but is technically a violation of the building code that RVs are certified to. (No penetration of vent pipes is allowed)
- Penetrations should be minimized. If using parallel connections, join wires together with branch connectors or a combiner box on the roof, then run one positive and one negative through the roof.
- A solar entry gland should be used to make a weather-proof connection though the roof.

Roof Penetration (Direct Access)

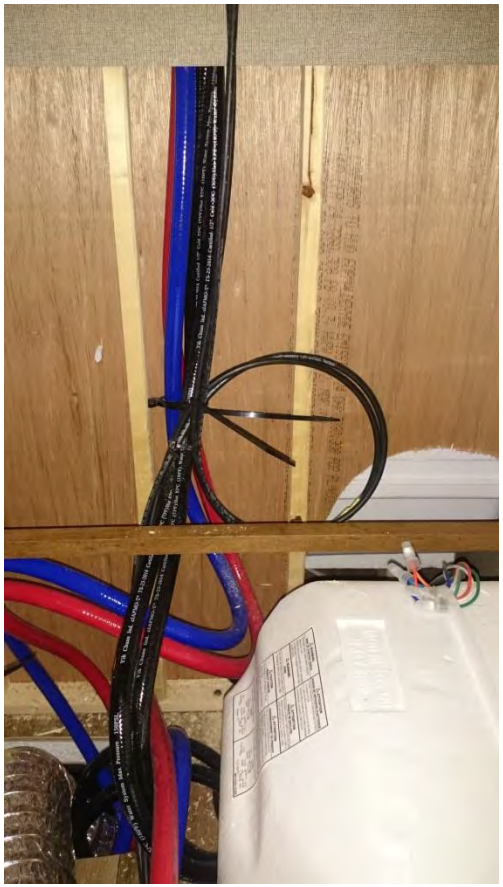


Brian Rowley removed the bathroom wall in his 337 to safely install solar wires.

Roof Penetration (Drilling)

Check for 120V wiring with a proximity voltage tester before drilling

Roof Penetration (Drilling)



Drill a very small pilot hole, then probe the space before finish drilling

Step 5 – Controls

How do I safely control the solar generated voltage going to the battery?

Solar Controller
PWM (Pulse Width Modulation)

PWM - PROs

- Durable, mostly available with passive heat sink style cooling
- A tried and tested solar controller which has been used for years
- Relatively inexpensive, depending on the voltage and current required
- Available in a range of voltage ranges like 12, 24 and 48V with current range of 5-60A
- Simple to install, operate and maintain

PWM - CONs

- To use a PWM controller on the solar system, the solar input nominal voltage must match the battery bank nominal voltage
- PWM is not available over 60A
- System growth is often limited
- Greater efficiency loss when batteries are at a low voltage

You must use a charge controller. Your batteries will be damaged if you don't!

Solar Controller

MPPT (Maximum Power Point Tracking)

MPPT - PROs

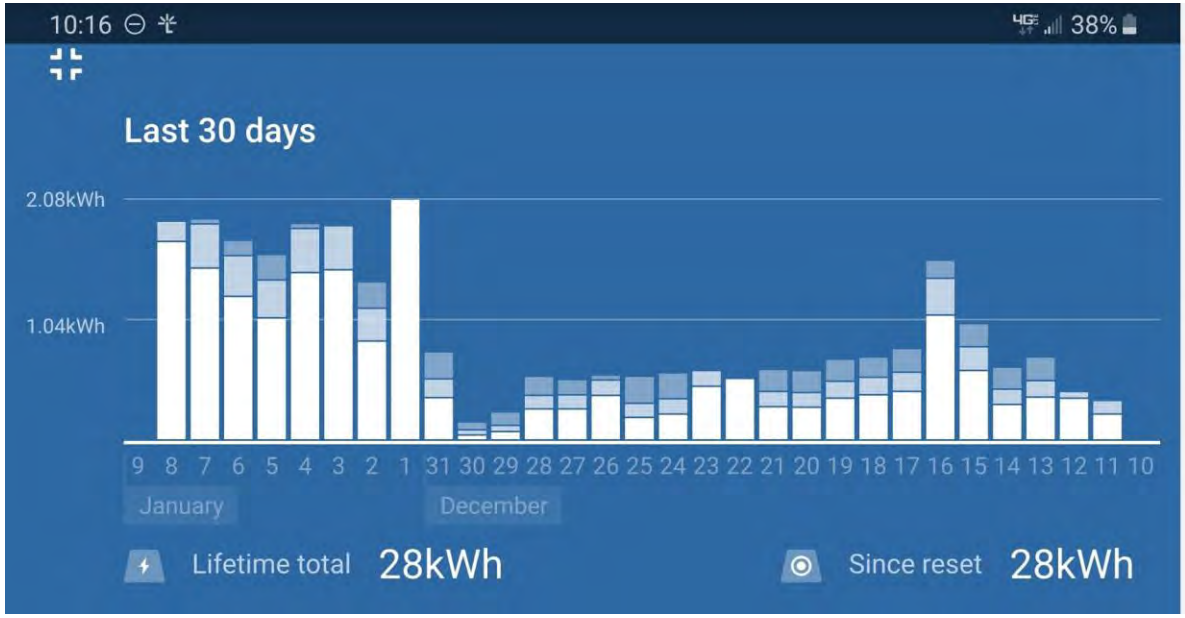
- Can increase charging efficiency by up to 30%
- Can be used on solar systems with a higher input voltage than the battery bank
- Available up to 80A
- Generally has a longer warranty than a PWM controller
- Greater flexibility allows for solar system expansion
- Input voltage is not restricted by the battery or system voltage
- Most come standard with reporting and alarm functions

MPPT - CONs

- More expensive than a PWM controller
- Generally larger in physical size
- Greater complexity with more expertise required by the installer to install and commission the controller

You must use a charge controller. Your batteries will be damaged if you don't!

Solar Controller
Victron MPPT Example



Example Systems

Many approaches to achieve the same goal:
Charge the batteries with power from the sun.

Portable Systems for Charging 1-2 batteries

95-Watt Furrion Panel
Connects to input port
$499

100-Watt HQST Panel
Connects to input port
with adapter
$189.99

Moderate Systems

Intermediate Systems

Complex Systems

Doug Meyers

Joey Carson

Other Equipment

Inverters
Converters
Inverter Chargers
Pig Tails
Transfer Switches

Inverters

An Inverter is required to convert 12V direct current to 120V Alternating Current

- The owner needs to understand their power needs.
- Power can vary from 100 Watts to 3,000 Watts.
- Modified Sine Wave vs. Pure Sine Wave
  - Pure sine wave is required for sensitive components.
- Inverter chargers with internal transfer switches are available.

Inverter Connections

Simple to Complex

- Direct Plug In
- Dedicated Outlet
- Connect to RV Power Inlet (Converter must be turned off)
- Transfer Switch (Converter must be turned off or wired out of the circuit when the inverter is energized)

Do NOT energize the converter via the inverter – Bad things happen!

Inverter Connections

Breaker Panels

- Allows powering desired outlets and equipment only.
- Helps prevent unintentional overload of the inverter.

Marie Palesch

Chris Hanson

Lance Wende

Resources

Grand Design Technical Forum – GDRVOwners.com

Facebook: Solar-Powered Grand Design (Must be a GDRV Owner)

Windy Nation: Windynation.com

Lithium Batteries: Battlebornbatteries.com

Victron Electronic Components: Victronenergy.com

Terminology

- Solar Panel – Silicon cells convert solar photons into electrons
- Battery Bank – One or more batteries used to supply RV electrical needs
- Converter/charger – Converts 120V Alternating Current (VAC) to 12V Direct Current (VDC).
- Inverter – Converts battery power into 120VAC.
- Fuse Block – Provides protection for the various electrical components.
- Transfer Switch – Switches from one power source to another. E.G. From shore power to generator or inverter power.
- Generator – Gasoline or propane powered device to provide 120VAC.
- Solar Controller – An electronic device that regulates the flow of energy into the battery.
- Shunt – Device connected to negative battery terminal to measure current consumption.
- Amp Hours – Number of amps consumed in one hour. Example: 15 amp hours means 15 amps were used in one hour.

Conclusion

Purpose of Solar

- This presentation should have given you information about:
  - Determining your battery usage
  - Sizing your battery bank
  - Determining how many Panels you'll need
  - How to hook them up, including running the wires.
  - What kind of equipment you'll need
  - Where to find information
  - Can I install a solar charging system myself?
  - Where to turn to for help