Solar Powered Ham Shack

Solar Powered Ham Shack

Why Have a Solar Powered Ham Shack?

1. Emergency Communications – on the air when the grid is down
2. No Power Supply = Less Noise
3. COOL factor – fun project to build!

BONUS: Limited backup AC power for your home during grid outage.

Solar Powered Ham Shack

Q: What is a Solar Powered Ham Shack?

A: Battery Powered Ham Shack…

with a Solar Battery Charger

Solar Powered Ham Shack

Anatomy of a Ham Shack?

Solar Powered Ham Shack

Anatomy of a Solar Powered Ham Shack?

Solar Panel(s)

Solar Charge Controller

Battery

Solar Powered Ham Shack

Anatomy of a Solar Powered Ham Shack?

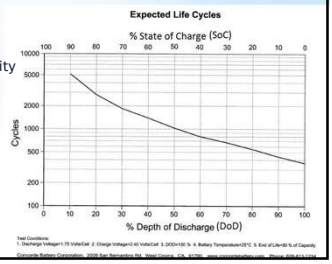
Battery

Batteries for Solar

Battery Chemistries - Lead Acid

- Most common battery chemistry
- Affordable (relatively)
- Readily available

- Only use 30-50% of battery capacity
- 5-7 year life expectancy
  (1,000 - 2,000 cycles)
- Lower energy density (40 Wh/kg)



Batteries for Solar

Battery Chemistries - Lithium Ion

Umbrella term for 6 different Lithium chemistries:

1. Lithium Cobalt Oxide
2. Lithium Manganese Oxide
3. Lithium Nickel Manganese Cobalt Oxide
4. Lithium Iron Phosphate
5. Lithium Nickel Cobalt Aluminum Oxide
6. Lithium Titanate

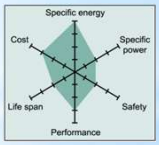
*BatteryUniversity.com

Batteries for Solar

Battery Chemistries - Lithium Ion

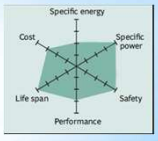
Lithium Cobalt Oxide

- Common in consumer electronics
- Highest energy density (150-200 Wh/kg)
- Low cycle live (500 - 1,000 cycles)
- Most unstable / **Dangerous** (YouTube videos)



Lithium Iron Phosphate

- Common in solar applications
- Lower energy density (90-120 WH/kg)
- Higher cycle life (2,000 - 10,000 cycles)
- Most stable / **Safe** Lithium chemistry



Batteries for Solar

Amp Hour Capacity (aka energy capacity)

100 Amp Hour battery can deliver:
100 amps for 1 hour
50 amps for 2 hours
20 amps for 5 hours
10 amps for 10 hours
1 amp for 100 hours
(assuming 100% depth of discharge)

Batteries for Solar

Combining batteries for additional capacity

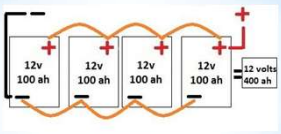
NEVER combine batteries that are:

Dissimilar Chemistry
Dissimilar Size
Dissimilar Age

Batteries for Solar

Combining batteries for additional capacity

Batteries in PARALLEL add Amp Hour Capacity
i.e.: Four 12 volt 100Ah batteries =
12v 400Ah battery bank

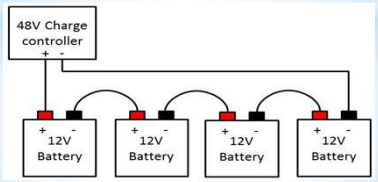


Batteries for Solar

Combining batteries for additional capacity

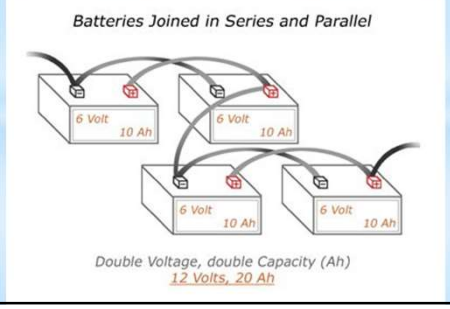
Batteries in Series add Voltage

i.e.: Four 12 volt batteries = 48 volt battery bank



Batteries for Solar

Combining batteries for additional capacity



Batteries for Solar

How Much Battery Do I Need in the Shack?

Icom 7100 2m FM 50 watts

Radio's receive amperage X hours listening?

1.2 amps X 8 hours = 9.6 Ah

Radio's transmit amperage X hours transmitting?

5.5 amps X 2 hours = 11 Ah

Battery's supported depth of discharge?

30% (lead acid battery)

Batteries for Solar

How Much Battery Do I Need in the Shack?

Icom 7100 2m FM 50 watts

(9.6Ah + 11Ah) / 30% DoD = 69 Ah Battery

(9.6Ah + 11Ah) / 50% DoD = 41 Ah Battery

(9.6Ah + 11Ah) / 80% DoD = 26 Ah Battery

Batteries for Solar

How Much Battery Do I Need for POTA / QRP?

Icom 7100 2m FM 10 watts

Radio's receive amperage X hours listening?

1.2 amps X 4 hours = 4.8 Ah

Radio's transmit amperage X hours transmitting?

3.5 amps X 2 hours = 7.0 Ah

Battery's supported depth of discharge?

80% (Lithium battery)

Batteries for Solar

How Much Battery Do I Need for POTA / QRP?

(4.8Ah + 7.0Ah) / 80% = 15Ah Lithium Battery

Solar Powered Ham Shack

Anatomy of a Solar Powered Ham Shack?

Solar Panel(s)

Solar Charge Controller

Battery

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Anatomy of a Solar Powered Ham Shack?

Solar Panel(s)

Solar Photovoltaic Panels

Polycrystalline Panels:

- Less efficient / lower power output (historically)
- Less expensive (historically)

Monocrystalline Panels:

- More pure silicon-additional refining
- More efficient (historically)
- More expensive (historically)

Bottom Line:

- Practically identical today
- Price / Watt ($0.50-$0.90/ watt +/-)
- Availability?
- Great for permanent install

Solar Photovoltaic Panels

Common Solar Panel Sizes

32 Cell Panel
100 Watts +/-
approx. 2'x4'

60 Cell Panel
300-375 Watts
approx. 3'x5'

72 Cell Panel
350-450 Watts
approx. 3'x7'

Solar Photovoltaic Panels

Anamorphous Thin Film Panels:

- Rugged & Durable
- Flexible
- Expensive ($1.00 - $2.00+ / watt)
- Inefficient (80% of mono/poly)
- Great for mobile / portable applications

Solar Photovoltaic Panels

Solar Panel Specifications

Typical 32 cell 100 watt panel

100W Polycrystalline Photovoltaic Solar Panel

Part #:	SOL-100P-01
Maximum Power (Pmax):	100 Watts
Open Circuit Voltage (Voc):	21.60 Volts
Short Circuit Current (Isc):	6.32 Amps
Max Power Voltage (Vpm):	17.4 Volts
Max Power Current (Imp):	5.75 Amps
Max System Voltage:	1000 VDC (600 VDC UL)
Dimensions:	40.0" x 26.4" x 1.2" [1015mm x 670mm x 30mm]
Weight:	17.6 lbs [8kg]
Max Series Fuse Rating:	8 Amps
Nom Operating Cell Temp:	45°C [+/-2°]

60 cell Canadian Solar KU panel

ELECTRICAL DATA | STC*

CS3K	315MS	320MS	325MS	330MS
Nominal Max. Power (Pmax)	315 W	320 W	325 W	330 W
Opt. Operating Voltage (Vmp)	33.1 V	33.3 V	33.5 V	33.7 V
Opt. Operating Current (Imp)	9.52 A	9.61 A	9.71 A	9.80 A
Open Circuit Voltage (Voc)	39.9 V	40.1 V	40.3 V	40.5 V
Short Circuit Current (Isc)	10.06 A	10.14 A	10.22 A	10.30 A
Module Efficiency	18.96%	19.26%	19.56%	19.86%
Operating Temperature	-40°C ~ +85°C			
Max. System Voltage	1500V (IEC/UL) or 1000V (IEC/UL)			
Module Fire Performance	TYPE 1 (UL 1703) or CLASS C (IEC 61730)			
Max. Series Fuse Rating	30 A			
Application Classification	Class A			
Power Tolerance	0 ~ + 5 W			

* Under Standard Test Conditions (STC) of irradiance of 1000 W/m², spectrum AM 1.5 and cell temperature of 25°C.

Solar Photovoltaic Panels

Solar Panel Performance

Standard Test Conditions (STC)

- Panel Temperate = 25˚C
- Irradiance = 1,000 watts / square meter

Solar Photovoltaic Panels

Solar Panel Performance

Temperature impacts panel voltage:

- 1% voltage increase for every 3˚C temp decrease
- 30˚C temp decrease from STC (-5˚C) = 10% voltage increase
- 30˚C temp increase from STC (55˚C) = 10% voltage decrease

Irradiance impacts panel amperage:

- 1,000 watts / square meter = 100% of rated amperage
- 800 watts / square meter = 80% of rated amperage
- 1,200 watts / square meter = 120% of rated amperage

Solar Photovoltaic Panels

Panel Orientation

Azimuth:

- South in northern hemisphere
- North in southern hemisphere

Elevation:

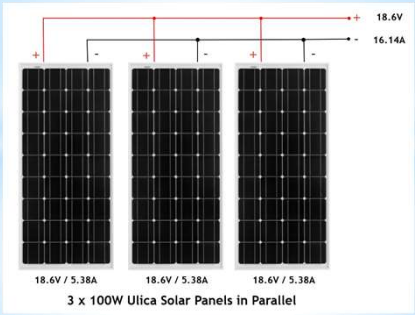
- Latitude = best year round production
- Latitude+15˚ = best winter production
- Latitude-15˚ = best summer production

Shading:

- Can reduce production 80% +/-

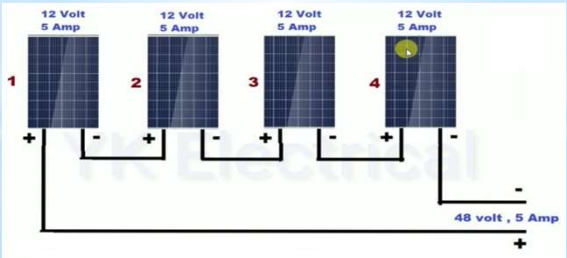
Solar Photovoltaic Panels

Parallel Configuration = Increased Amperage



Solar Photovoltaic Panels

Series Configurations = Increased Voltage



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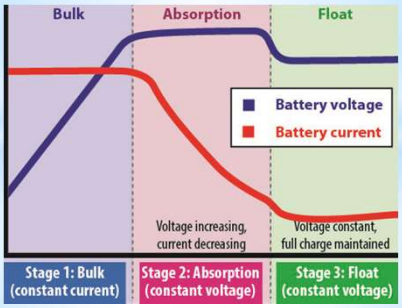
Solar Charge Controllers

3-Stage Battery Charging



Solar Charge Controllers

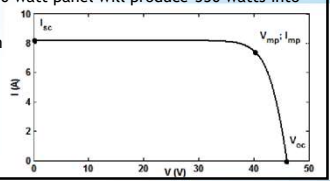
Pulse Width Modulation (PWM)

- Original / older charge controller technology
- Inexpensive ($40 - $150 range)
- Directly connects solar array to battery
- Uses pulse width modulation to taper charge current in absorb and float stages.
  - Array voltage is pulled down to battery voltage - **very inefficient**
  - i.e.: 35 volt 10 amp (350 watt) solar panel will only produce 12 volts & 10 amps (120 watts) into the battery (35% efficient)
  - i.e.: 18 volt 5.5 amp (100 watt) solar panel will only produce 12 volts & 5.5 amps (66 watts) into the battery (66% efficient).

Solar Charge Controllers

Maximum Power Point Tracking (MPPT)

- Newer charge controller technology
- Expensive ($100 - $1,500)
- Intelligently find the maximum power point of the solar panels I-V curve to maximize solar production.
  - 95% - 98% efficient, so a 350 watt panel will produce 330 watts into the battery.
  - Supports solar voltage from Battery+10v up to 150v typically.



Design Goals

Estimate electrical loads (Ah)

Size battery to meet / exceed loads

- 2x – 3x the energy needed for a lead acid battery
- 200-300Ah lead acid battery = 100Ah usable capacity
- 125 Ah Lithium battery for 100Ah usable capacity

Size solar array to recharge battery in 1 sunny day

- Solar should be 1/3 the battery's usable watt hour capacity
- 100 watt array for a 300 usable watt hour battery

Solar Powered Ham Shack

Questions?