Solar Power for the Service-Minded Amateur Radio Volunteer

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September, 2021

Goals of this talk

- Add to your family's resource opportunities for responding to utility power loss
- Accomplish 1 of our Goals in the **ARES(R) Integrated Preparednesss Plan.**
- Increase your Field Day scoring by **100 points**(equivalent to 50 voice contacts, *possibly hours and hours of Field Day effort*)
- Avoid spending $$ on over-priced "solutions"
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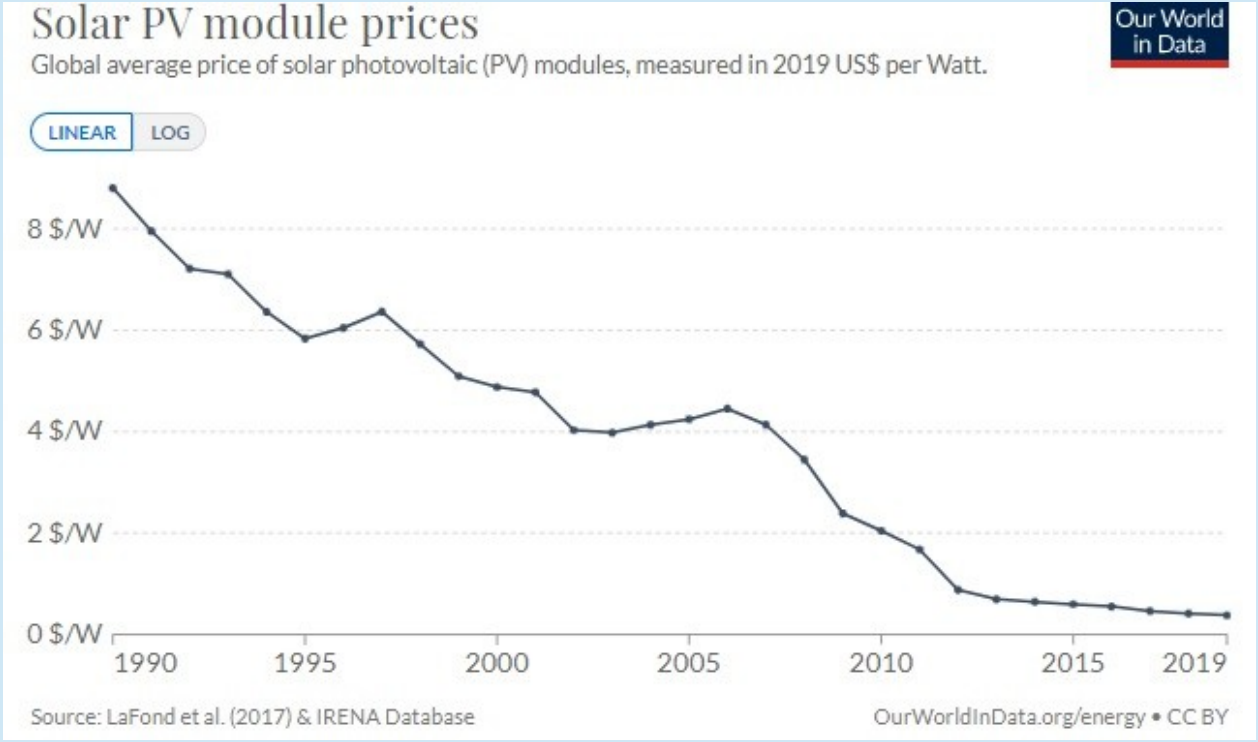
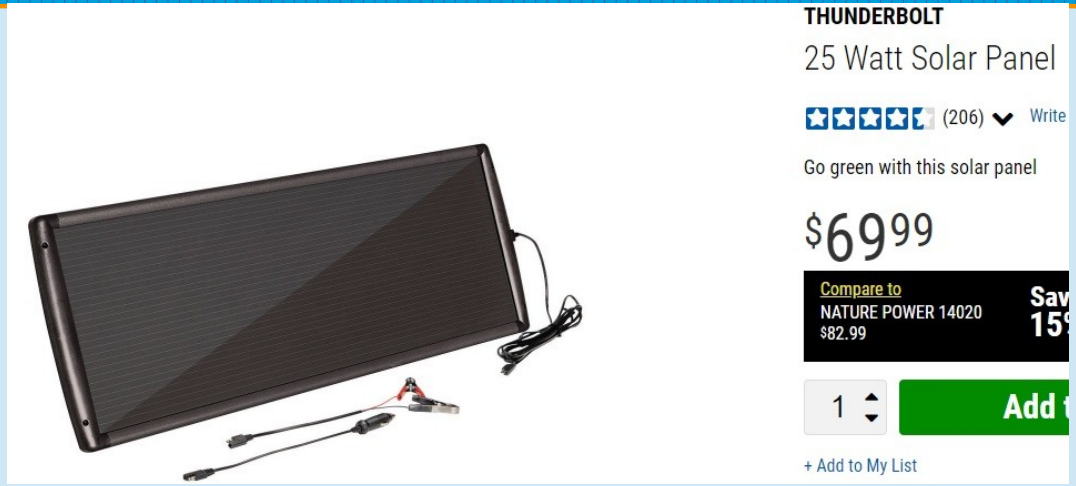
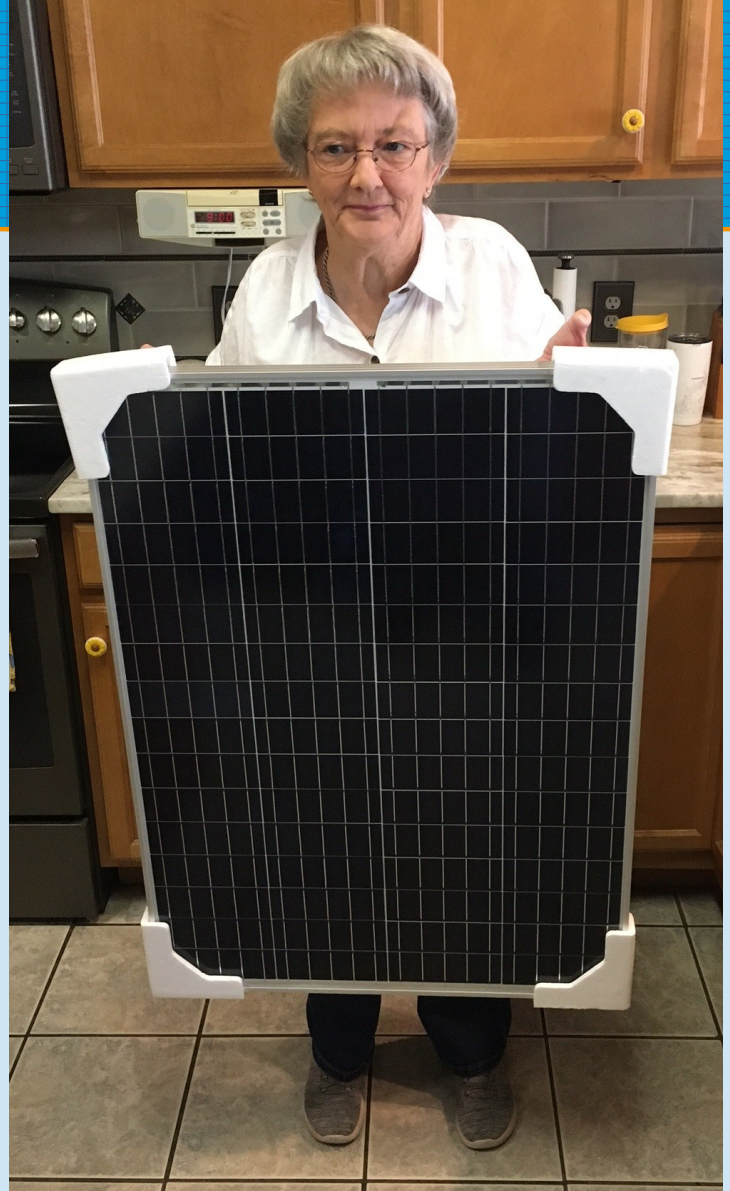
Dropping Prices



High / Low Prices – Your Choice

- Typical industry prices $0.75/watt
- Harbor Freight prices can be as much as $2.50/watt (25 watts for $70)
- You don't have to pay those prices….
- 100W panel for $80.





Bare connectors easy to find

YXGOOD Solar Connectors MC4 Male/Female IP67 Waterproof Solar Panel Cable Connectors (6 Pairs Solar connectors)

Brand: YXGOOD

4.5 ★★★★½ 90 ratings

Amazon's Choice for "solar panel connectors mc4"

Price: $8.99 prime & FREE Returns

Get $50 off instantly: Pay $0.00 ~~$8.99~~ upon approval for the Amazon Rewards Visa Card. No annual fee.

May be available at a lower price from other sellers, potentially without free

- Typical large scale solar prices are well below $1/Watt
- Astroenergy: 69 **cents** per watt in single unit quantity

ASTRONERGY

Astronergy CHSM6612M-370-HV Silver Mono Solar Panel

Astronergy 370 watt Module Silver Mono CHSM6612M/HV – 40mm Frame 1500V

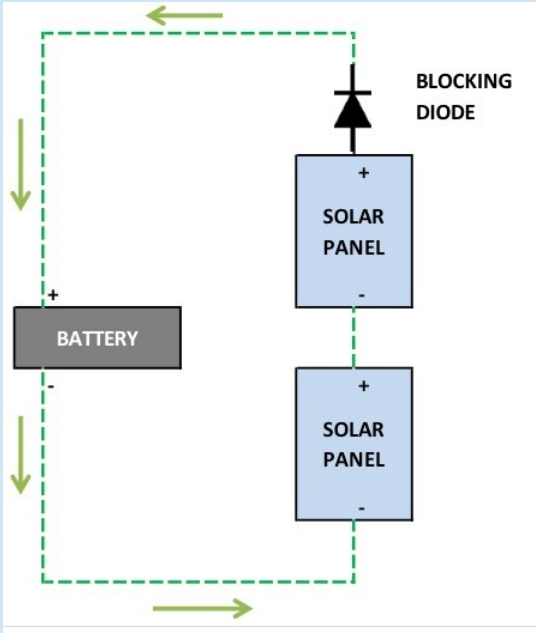
$257.00

Qty 1 ADD TO CART

SKU: 1977441
Mono PERC, Solar Panels for Sale
Brand: Astronergy

Photons create current flow

Solar panels are made out of semiconductor DIODES. Normally we use diodes to control the flow of electrical current, allowing it to go in only one direction. In the case of a the most common types of solar cells, a P-N semiconductor junction (diode) absorbs energy from a photon of light, causing the generation of an electron/hole pair; the electron is released from its parent atom by the absorbed energy. This electron then flows out of the cell, through a circuit doing useful work, and comes back to the other connector of the cell to recombine.



The maximum theoretical voltage produced is on the order of 0.5 to 0.6 VDC, and thus doesn't cause the PN junction to conduct. Not much of the current is wasted in internal shunt conduction.

The face of the solar cell is made out of a conductive, but transparent, semiconductor material, with silvered contacts aggregating the current produced.

There are many different possible chemistries possible for the solar cell, with different characteristics, advantages and disadvantages.

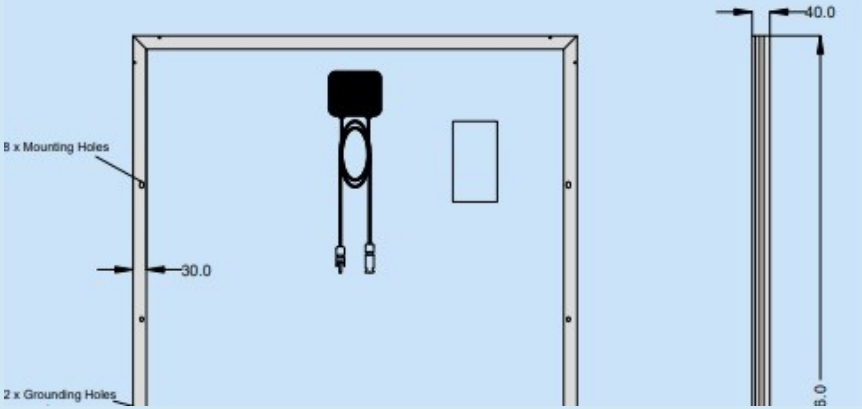
Series Solar Cells = PANEL

A typical solar panel has many such solar cells electrically arranged in SERIES to produce a higher voltage. Consumer panels may have an open circuit voltage (no load) of approximately **18 volts** (making charging of a 12 volt battery convenient) whereas panels intended for serious power generation usually have **60 or 72 cells in series**, and make an **open circuit voltage of greater than 30 volts**.

How to read Specifications

60-CELL MONOCRYSTALLINE HOME PV

DIMENSIONS FOR 60M HOME PV SERIES



ELECTRICAL DATA (STC)

Peak Rated Power	P_{mpp} (W)	320	315	310	305
Maximum Power Voltage	V_{mpp} (V)	34.10	33.70	33.54	33.60
Maximum Power Current	I_{mpp} (A)	9.37	9.33	9.27	9.07
Open Circuit Voltage	V_{oc} (V)	40.50	40.32	40.13	39.98
Short Circuit Current	Isc (A)	10.20	10.16	10.22	9.67
Module Efficiency *	Eff (%)	19.21	18.92	18.78	18.28
Maximum Series Fuse Rating	MF (A)	20	20	20	20
Power Output Tolerance	[- 3 , + 3] %				

STC - Standard Test Conditions: Irradiation 1000 W/m2 - Air mass AM 1.5 - Cell temperature 25 °C

* Calculated using maximum power based on full positive output tolerance [-3 , +3] %

Solar Efficiency

The efficiency of solar panels, considering the electrical output versus the solar energy incident to them, is generally less than 25%

The theoretical maximum efficiency of a single cell is on the order of 30%. Additional cells can be placed on top of each other to obtain more power from the solar radiation.

The incident energy of full sun is approximately 1120 watts per meter-squared at ground level on the Earth. (This is why being in full sun on Field Day can dangerously raise your body temperature over time.)

With a typical efficiency of 20%, that means to produce 200 watts of electrical power requires approximately 1 meter-squared of solar panel. **That works out to about 20 watts per square foot, from an incident energy of about 100 watts per square foot.**

Matching Impedances

- Solar panels, just like a transmitter, have an output impedance (voltage / current)
- Maximum power transfer when MATCHED to the impedance (voltage/current) of BATTERY or LOAD
- Expensive batteries need to be charged properly to avoid DAMAGE
- SOLUTION: Smart Charge Controllers – levels of smarts
  - Pulse width modulated controllers – cheaper, less efficient
  - Maximum power point tracking – more expensive, more efficient

Choosing a Charge Controller

- 1. Has to accomodate the BATTERY VOLTAGE you plan.
- 2. Has to accomodate the highest OPEN CIRCUIT voltage of the solar panel (cold day)
- 3. Able to move the currrent needed to charge the battery at the required rate.

Cheap Controller Specs

Specification	Value	Comment
Maximum input voltage	60V	Our panel produces a maximum below 40 VDC
Battery Voltage Nominal	12/24	Unit auto-detects the battery voltage
Battery Type	Gell	Unit uses charging voltages appropriate for GELL CELLS, which means that it will NOT do an equalization (higher voltage/current) phase. Boost voltage: 14.5V/29V Float Voltage: 13.7/27.4V
Maximum output current	15A	We rarely see it get above 10A

Well-spec’d MPPT

HQST 20A MPPT Solar Charge Controller with Bluetooth LCD Display

- Auto-recognition of 12/24V battery system
- 100Voc max PV input voltage
- 1.2KW max PV input power
- Allows max 25% exceeding rated power
- Battery temperature compensation function
- Compatible with sealed, gel, flooded, and lithium batteries
- Die-cast aluminum design allows for efficient natural heat dissipation
- Multiple electronic protections: ov
  overheat/reverse/overload/short-
- Built-in Bluetooth module for mo
  settings

HQST MPPT Solar Charge Controller 20 Amp Negative Ground Controller with Bluetooth LCD Display, 12V/24V DC Input Solar Panel Regulator for Gel Sealed Flooded and Lithium Battery

Visit the HQST Store

#1 New Release in Renewable Energy Controllers

Price: ~~$79.99~~
Prime Price: $71.99 ✓prime & FREE Returns
You Save: $8.00 (10%)
Includes $8.00 Prime savings
Coupon ☐ Save an extra $5.00 when you apply this coupon.
Details

- There are LOTS of MPPT controllers out there now.
- Likely because of cheap MOSFET or even more advanced semiconductors.
-

How much power do you need?

- Ham radio HF: 200W peak, maybe 50-75 watts average?
- Refrigerator: 2 KILOWATTS START POWER – then 100 watts; they run about 25-40% duty cycle. You will not start a fridge with a 1 kw inverter….. Expect to need lots of batteries to provide the starting impulse….
- LED lightbulbs – <15 watts each
- Small window AC: 500 watts

Transceiver	Output RF power	Typical Supply Consumption
VHF/UHF	40W	80W, or about 6-7 Amps @ 13V Power is continuous when transmitting
HF	100W	200+W or about 15-20A @ 13V However, when using SSB-Voice the duty cycle is perhaps 40% rather than continuous.
HF - digital	Assume 50 watts	Approximately 10A @ 13V

How much **energy** do you need?

- Field Day: 100W HF radio x 1 hr = approx 75 watt-hours (6 AHr@12V)
- Refrigerator x 24 hours = Expect 2kW-hours
- Power = volts x amps
- Energy = power x time

Battery Technologies

- Older Technologies
  - Flooded lead-acid: cheapest, heaviest, high current impulse
  - Sealed lead-acid – pricey
  - Absorbed glass-matt lead acid – pricey, heavy
  - Sensitive to TIME UNCHARGED: plates “Sulfate“ – crystals, difficult/impossible to recover….

Lithium Batteries

- LiPo batteries – risk of fires?
- LiFePo4 batteries – no significant fire risk
  - Pricey
  - Sealed
  - Typically include “Battery Management System“ (Series MOSFET) – limits peak currents (not useful as engine starting battery)
  - Many times the number of cycles – becoming competitive in home installations.

Field Day or Emergency Service

- Sun doesn’t shine at night
- Batteries needed for overnight service
- Lead Acid batteries suffice for Field Day – LiFePo4 make it even easier
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Dropping LIFEPO4 Prices

100 Ahr for $360 Amazon
Previously, $1000 range

Prices are all over the place, don't make much sense...buyer beware.

12.8V 200AH LiFePO4 battery

LiFePO4 battery internal structure

12.8V 100AH LiFePO4 battery specifications

- Rated Capacity (0.2C): 100Ah / 1280Wh, impedance: ≤ 8mΩ
- Charge voltage: 14.2V~14.6V, Rated voltage: 12.8V
- Max Depth of Discharge (DoD): 100%
- Max charge current: 100A
- Max continuous discharge current: 100A
- Peak discharge current: 300A (Duration: less than 5 seconds)
- Standard charge current: 20A, Charging time approximately 6 hours
- Operating temperatures: Charge 0°C~50°C(32°F~122°F), Discharge -20°C~60°C(-4°F~140°F), Storage -20°C~50°C(-4°F~122°F)

- NOTE: When you need to connect multiple batteries in series or parallel, you need to keep the battery voltage difference between two adjacent batteries within 20mV.

Handling 115VAC needs

- Need to convert from battery voltage
- Need to deal with Radio Frequency Interference

Inverter

Simple setup that provides 115VAC to run Anything that needs 115VAC instead of 12VDC (e.g. computer, older radio)

Total Cost about $50.

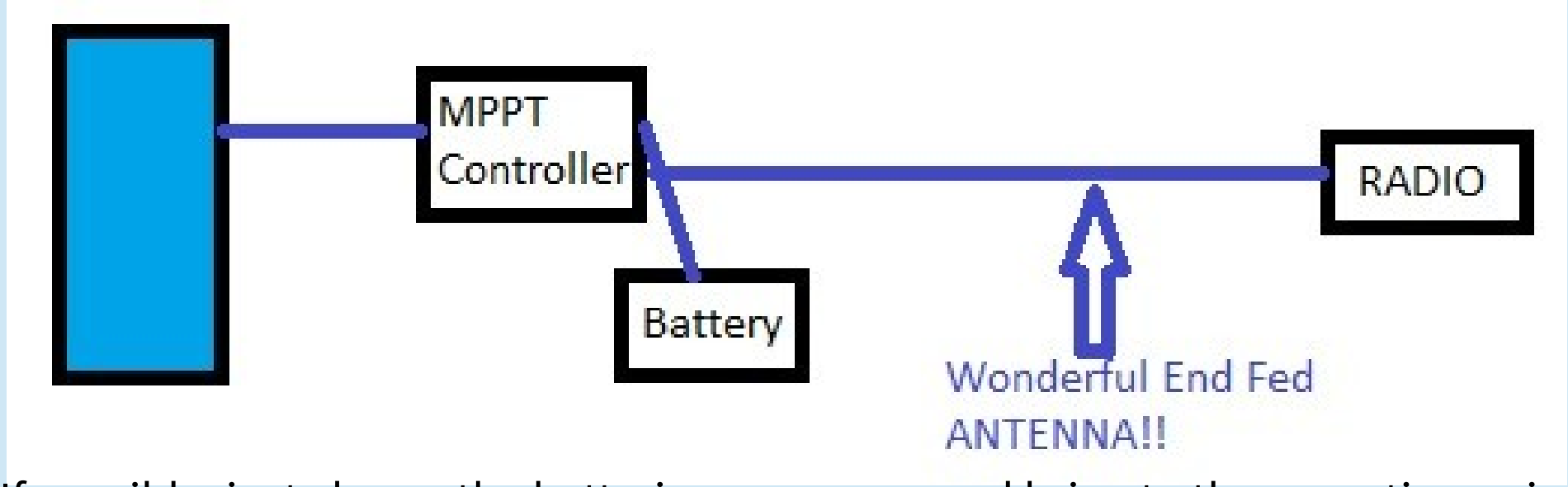
Power pole input…..
115VAC output.

You can use a sine-wave inverter if desired; prices are coming down nicely

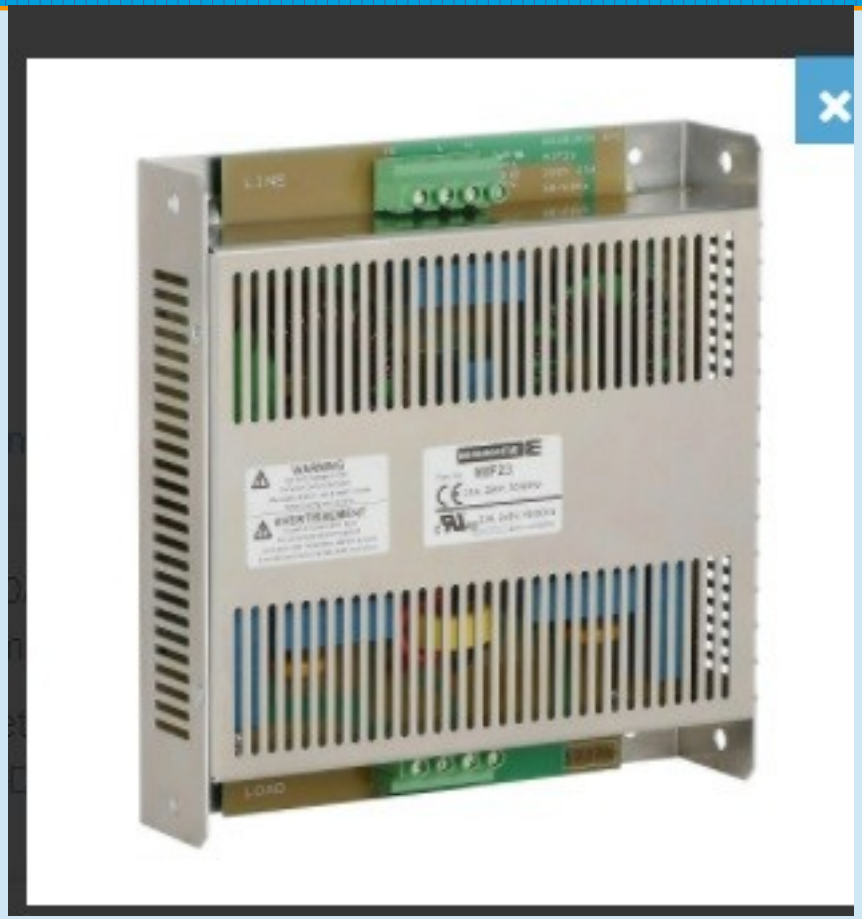
Warnings about home systems….

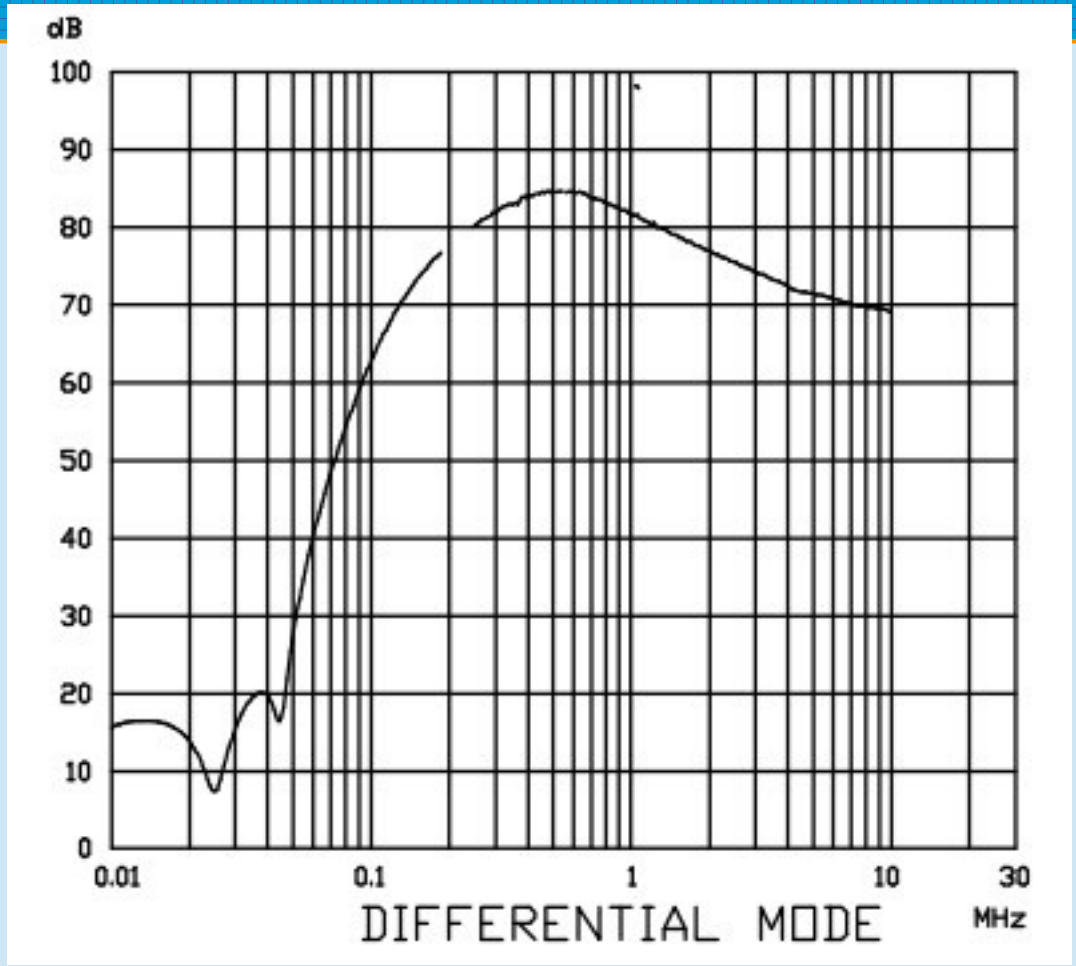
- MPPT controllers typically make RFI
- Series strings of up to 700 volts and beyond are used often today
- Some of those systems generate a LOT of RFI
- Can be difficult to control the noise
- I have more experience with 48VDC battery-based, older systems where some RFI control is possible with ferrites & filters.
- Filters must be heavy-duty to handle home sized systems….

Fantastic Wide Band Spark Transmitter



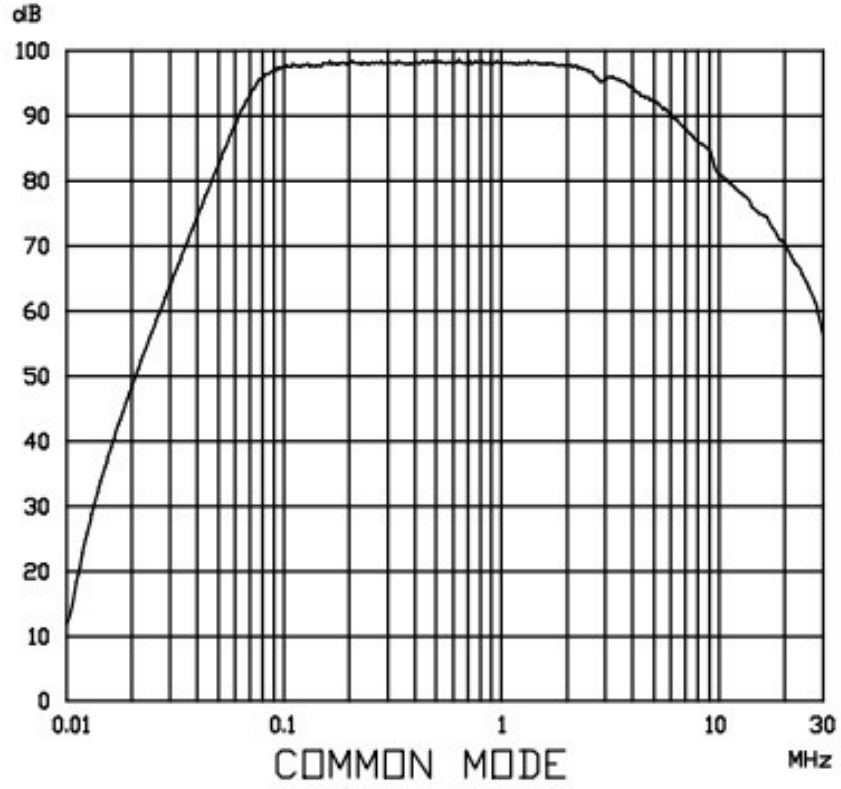
If possible, just charge the batteries way away, and bring to the operating point.
If not, then add lots of common/diff mode filtering (TOROIDS)




dB
100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
10
30
MHz
DIFFERENTIAL MODE

ROXBURGH ELECTRONICS LTD
FILTER INSERTION LOSS CHARACTERISTICS
CISPR 17 - 50 OHM METHOD

MIF23



Ferrites kitsandparts.com

551	2 pieces FT140-43 ferrite toroid (1762 available) Specs	5.50		80 g
552	30 pieces FT140-43 ferrite toroid (1762 available) Specs	65.00		1650 g
554	2 pieces FT140-61 ferrite toroid (2162 available) Specs	6.00		100 g
555	30 pieces FT140-61 ferrite toroid (2162 available) Specs	65.00		1800 g
557	2 pieces FT140-77 ferrite toroid (5 available) Specs	6.00		100 g
558	30 pieces FT140-77 ferrite toroid (5 available) Specs	70.00		1650 g
559	1 pieces FT240-31 ferrite toroid (473 available) Specs	10.00		180 g
560	10 pieces FT240-31 ferrite toroid (473 available) Specs	85.00		1850 g
561	1 piece FT240-43 ferrite toroid (800 available) Specs	8.00		170 g
562	10 pieces FT240-43 ferrite toroid (800 available) Specs	75.00		1700 g
563	40 pieces FT240-43 ferrite toroid (800 available) Specs	280.00		6800 g
564	1 piece FT240-52(K) ferrite toroid (17 available) Specs	13.00		175 g
565	10 pieces FT240-52(K) ferrite toroid (17 available) Specs	120.00		1750 g
566	1 pieces FT240-61 ferrite toroid (574 available) Specs	10.00		170 g
567	10 pieces FT240-61 ferrite toroid (574 available) Specs	95.00		1700 g
568	1 pieces FT290-43 ferrite toroid (28 available) Specs	14.00		220 g
575	3 each TO5/39 Small Aluminum Heat Sink (1616 available) Specs	3.00		14 g
579	5 each BNC Jacks Chassis Mount w/nut and solder tab (800 available) Specs	4.50		27 g

Some people prefer slightly different mixes for HF but -43 works well.

What we went over

- Solar is getting cheaper and cheaper
- Modest sized 100W panels are now inexpensively available <$1/W
- MPPT controllers are widely available
- Battery technology offers many options
- Powering Field Day alternative power requirements = **easy**
- Powering emergency home systems now relatively modest – compared to some pricey ham radios!!
- RFI solutions are generally filters / toroids / lead dress, allows using inverters, computers, digital modes without problems at modest power solar systems.