

SOLAR POWER SYSTEM DESIGNS



- **Off-Grid**
- **Ham Radio Application**



**Fredericton Amateur
Radio Club (FARC)**

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SOLAR POWER DESIGN – OFF GRID



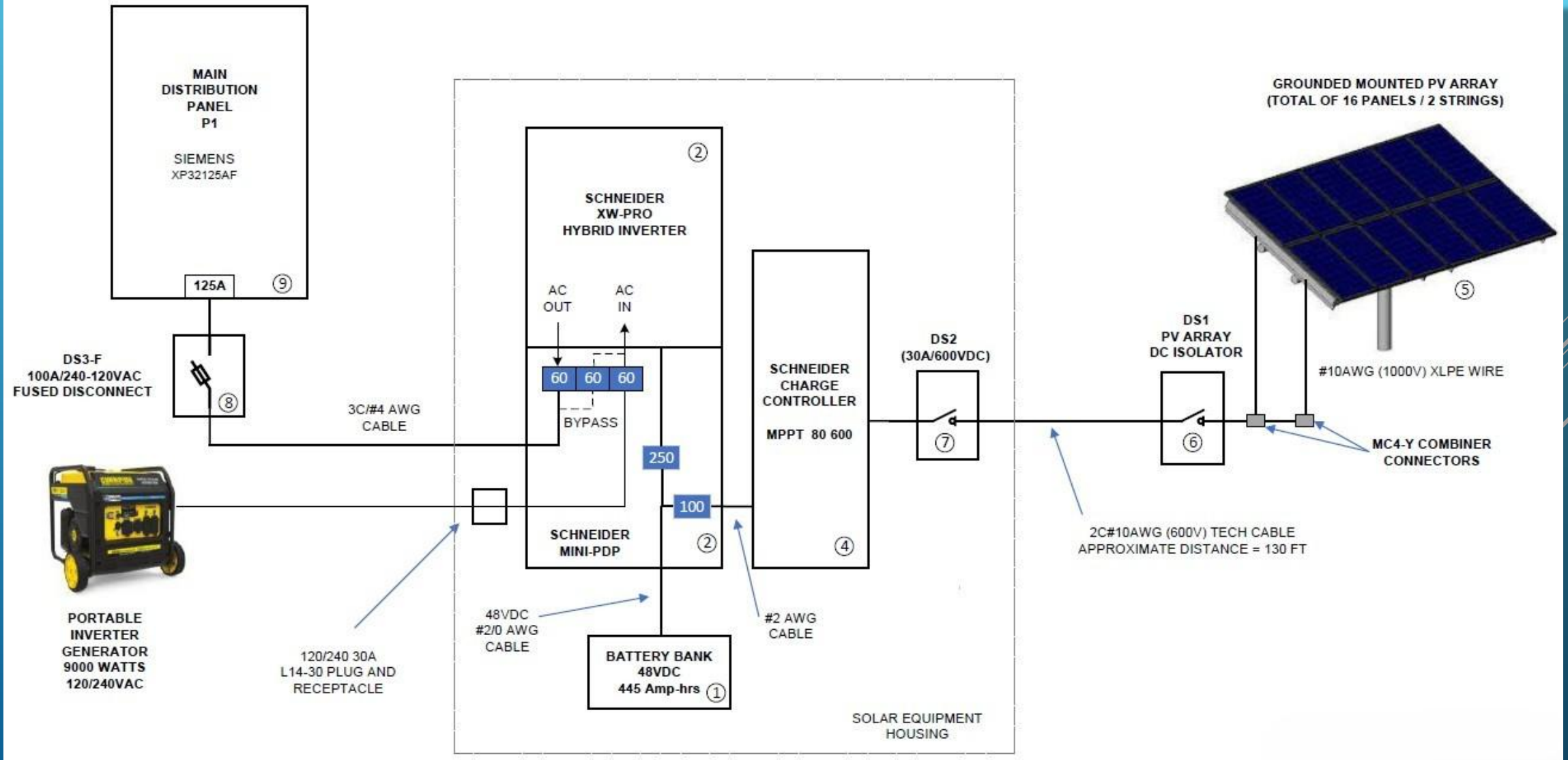
System Design Parameters

- ❑ System designed for an Off-Grid installation, no connection to the grid.
- ❑ Compliance to CEC 21.1-21, 9, SECTION 64
- ❑ Hybrid Inverter/MPPT Charge Controller/Battery system producing 120/240 VAC from a 48 VDC DC system.
- ❑ String Inverter Configuration, using two strings connected in parallel at the solar array (as opposed to micro-inverter designs).
- ❑ Utilizing Schneider Electric solar equipment rated for 8 KW.
- ❑ Hybrid Inverter system capable of connecting to the grid (if necessary) and a generator system.
- ❑ Load list and load demand profiles are required for solar system sizing.
- ❑ The normal heavy electrical loads in a conventional home, such as the hot water tank, cooking stove and dryer, are all on propane.
- ❑ Batteries are Flooded Deep Cycle Lead Acid type – 48 vdc at 445 AH.
- ❑ Solar panels are ground mounted stands located about a 120 ft from the house.

System Design Parameters - continued

- ❑ String Inverter design as opposed to micro-inverter design
- ❑ String Inverter design more adapt for total off-grid applications
- ❑ Micro Inverter design mainly for grid-tie systems with no battery backup.
- ❑ For Off-Grid, the micro inverter design has limitations:
 - ✓ No Standalone start – needs an active AC voltage and frequency reference
 - ✓ “Grid following” devices – they need to be “tricked” into turning on with a 120/240 VAC source such as a separate hybrid inverter connected to batteries.
 - ✓ Because it produces 240 VAC only, you need a split phase source to produce 120 VAC.
 - ✓ The total cost of micro-inverters and hybrid inverter with batteries can be cost prohibitive.

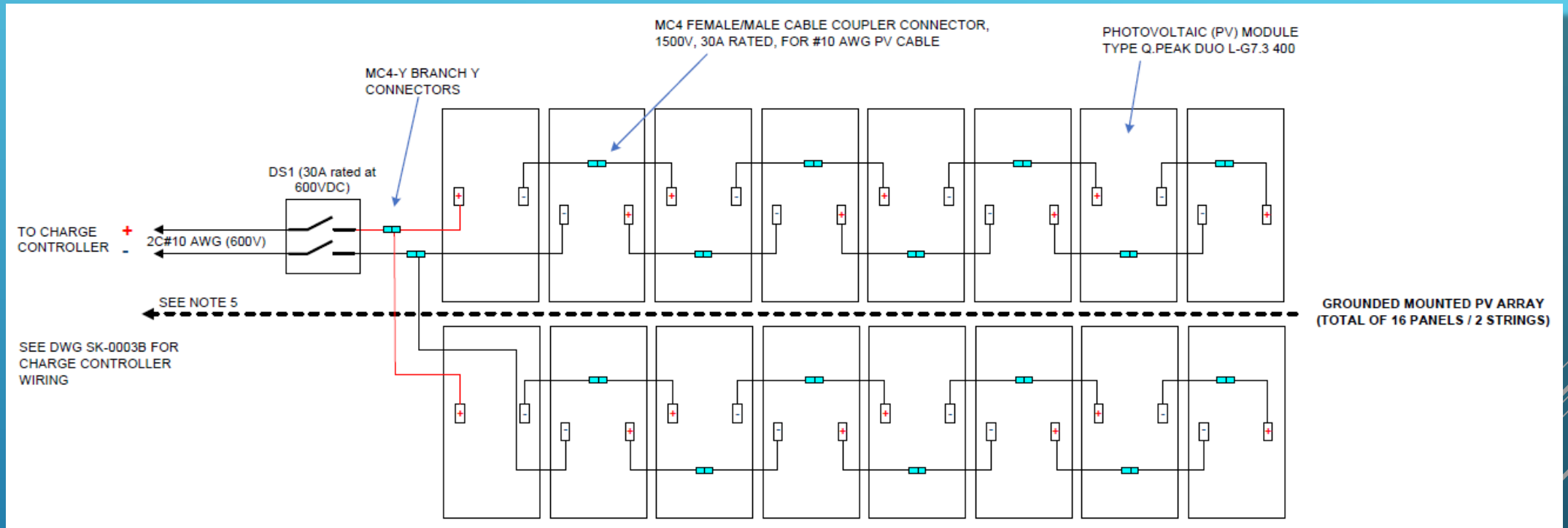
6.5 kW String Inverter Design



EQUIPMENT LIST:

1. Rolls S6 L16-HC Lead Acid Batteries – 445 Amp-Hrs at 6vdc each
2. Schneider 6848 XW-PRO Hybrid Grid Tie Inverter:
3. Schneider RNW865101301 80A/600vdc Schneider MPPT Charge Controller
4. Schneider RNW865684821 Mini Power Distribution Panel
5. Solar Panels: TYPE Q.PEAK DUO L-G7.3 400 Watt
6. DS-1 Square-D CHU361RB Non-Fused NEMA 3R Disconnect Switch
7. DS-2 Square-D CHU361 Non-Fused NEMA 1 Disconnect Switch
8. DS-3-F Square-D CD223NRB NEMA 3R Fused Disconnect Switch
9. Panel 1 - SIEMENS XP32125AF Main Distribution Panel

Solar Panel Wiring: String Inverter Setup



- ❑ Each panel, in each string, is wired in series, producing an overall voltage of 350 to 420 vdc.
- ❑ The two strings are then paralleled to produce 6,400 watts of power to the MPPT controller.

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Solar Panel Array: Front and Back



Solar Equipment Housing

XW Pro
8 kW Inverter

XW Pro
Mini-PDP Panel

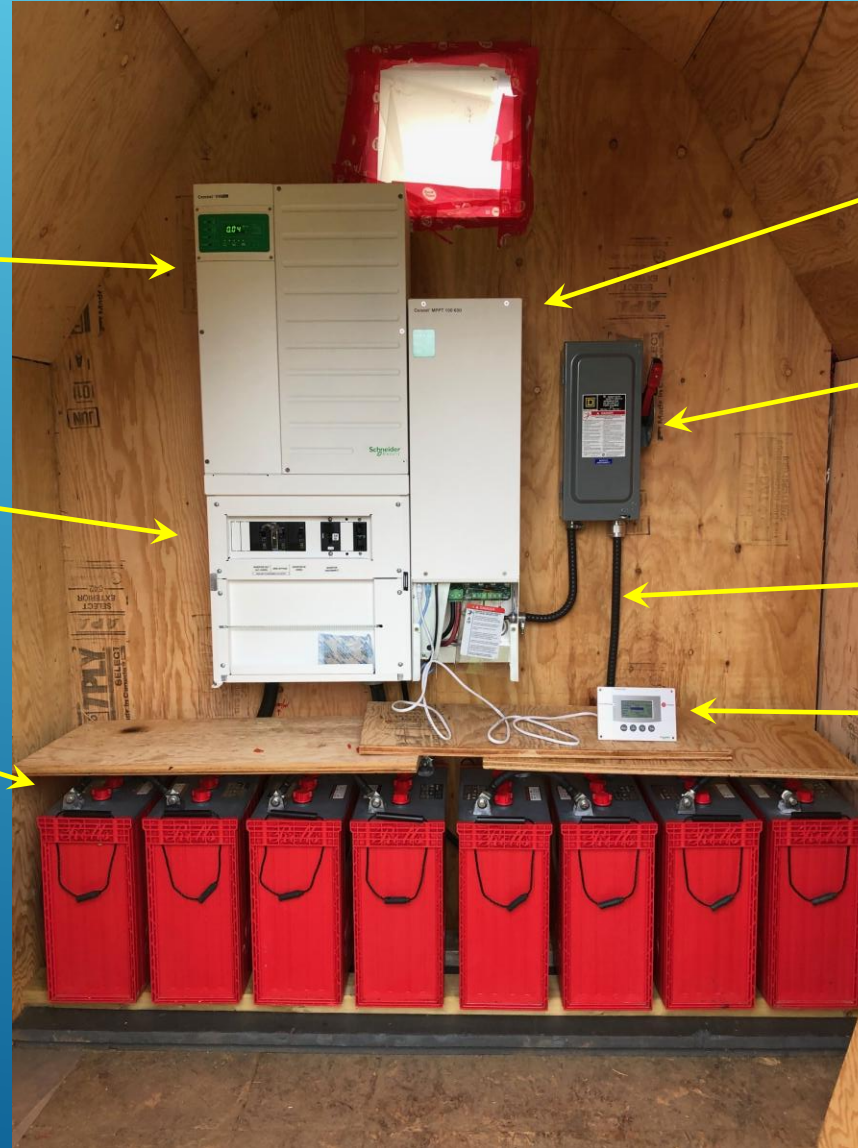
Rolls Batteries
6vdc / 440 AH

Conext MTP
80A/600VDC
Charge Controller

30A Disconnect
Switch

Incoming Power
from Solar Array

Conext SCP
System Control Panel



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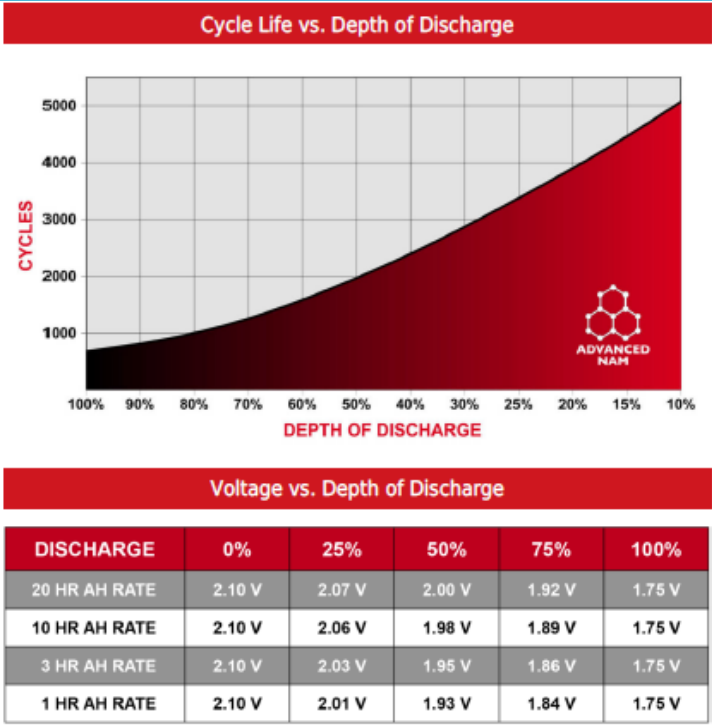
Batteries:
8 x Rolls S6 L16-HC



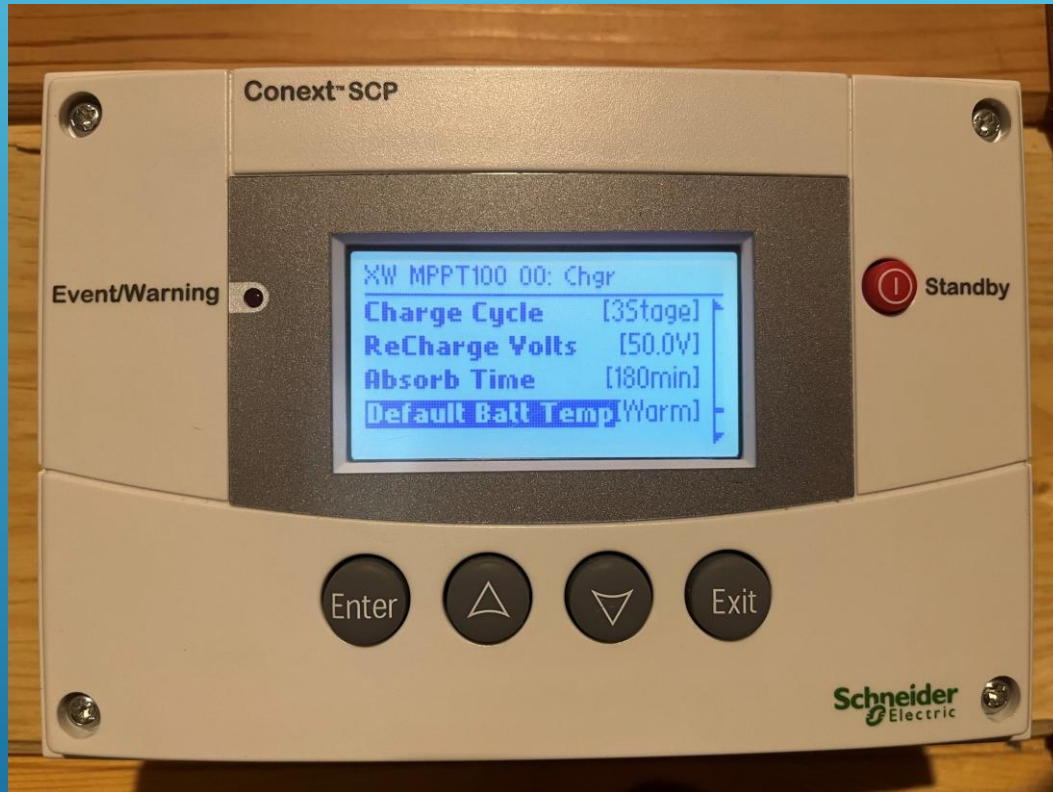
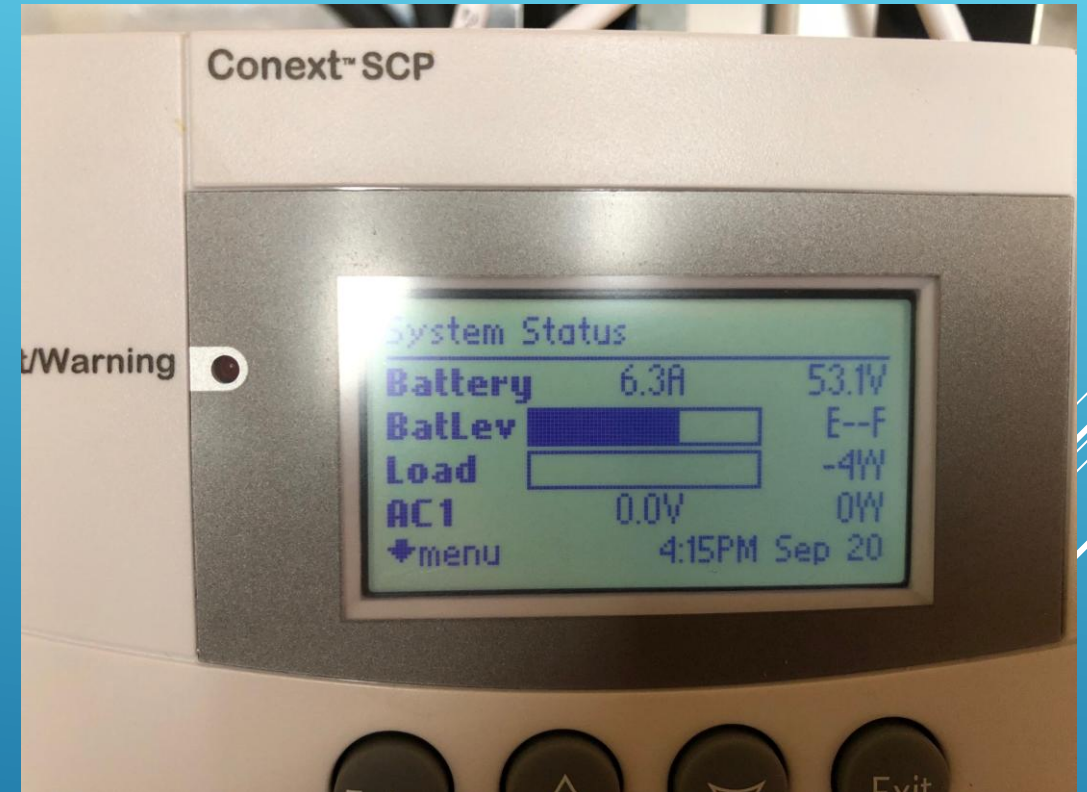
Batteries rated
at 445 AH



Charge				
Charge Voltage Range	2.45-2.5 V/cell @ 25°C (77°F)			
Float Voltage Range	2.25 V/cell @ 25°C (77°F)			
Recommended Charge Current	50 A			
Maximum Charge Current	85 A			
Self-Discharge Rate	5%-10% per month at 25°C (77°F)			
Capacity				
Cold Crank Amps (CCA) 0°F / -18°C	1040			
Marine Crank Amps (MCA) 32°F / 0°C	1299			
Reserve Capacity (RC @ 25A)	861 Minutes			
Reserve Capacity (RC @ 75A)	226 Minutes			
Capacity Affect by Temperature	40°C (104°F)	25°C (77°F)	0°C (32°F)	-15°C (5°F)
	105%	100%	75%	50%
Hour Rate	Capacity / AMP Hour		Current / AMPS	
@ 100 Hour Rate	512 AH		5.12 A	
@ 72 Hour Rate	498 AH		6.92 A	
@ 50 Hour Rate	481 AH		9.61 A	
@ 20 Hour Rate	445 AH		22.25 A	
@ 15 Hour Rate	418 AH		27.89 A	
@ 10 Hour Rate	401 AH		40.05 A	
@ 8 Hour Rate	383 AH		47.84 A	
@ 5 Hour Rate	356 AH		71.20 A	
@ 1 Hour Rate	209 AH		209.15 A	
Ampere hour capacity ratings based on specific gravity of 1.280 at 27°C (80°F). Reduce capacities 5% for specific gravity of 1.265 and 10% for 1.250.				



Programming Panel: Conext SCP (System Control Panel)



XV Pro Schneider systems uses XanBus to communicate between Schneider equipment
The SCP is used to configure and monitor the solar power system

Results and Observations

- ❑ Schneider solar systems are very robust, fairly easy to configure, and operate flawlessly.
- ❑ The Inverter and MTTP controller communicate settings and information via XanBus.
- ❑ With the Deep Cycle batteries, equalization is required at least twice a year.
- ❑ With the size chosen, in the dark winter months when there more than 2 days of cloud cover, the generator is required to top up the batteries. Only takes about 30 to 45 minutes to charge the batteries.
- ❑ An inverter type generator is required to charge the batteries and provide clean 60 Hz power through the inverter.
- ❑ Equipment designed with RFI and EMI compliance FCC Part 15(B), Class B producing little to no interface to HF radio equipment.
- ❑ Advantages:
 - ✓ No power bill
 - ✓ No worry about power outages
- ❑ Disadvantages:
 - ✓ Initial costs can be expensive
 - ✓ If not sized properly, aux power sources may be required

Solar Power in the Barn:

- ❑ 400 watt PV
- ❑ 2000 Watt Inverter
- ❑ 12 VDC 280 AH LiFePO4 battery
- ❑ Used for mainly lights, small heater for the chickens in the winter and receptacles
- ❑ This setup does produce some hash and noise on the HF bands



Solar Power in the Cabin: (In progress)

- ❑ 400 watt PV
- ❑ 3500 Watt Inverter
- ❑ 12 VDC 310 AH LiFePO4 battery
- ❑ Used for mainly lights, a few receptacles, and a small refrigerator
- ❑ This setup does produce some hash and noise on the HF bands



Results and Observations

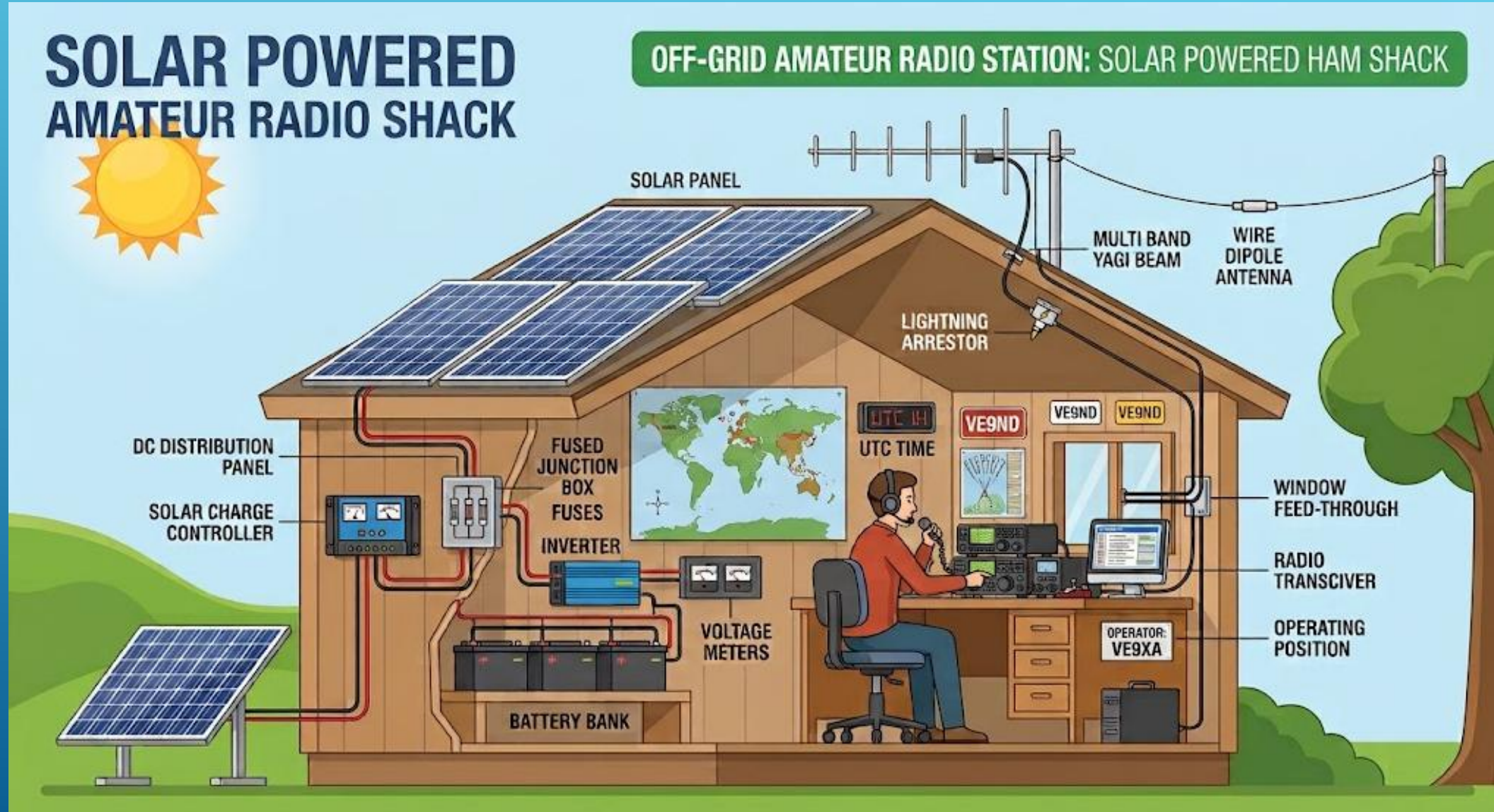
- ❑ These systems are small and designed for light loads.
- ❑ The batteries are LiFePO4
- ❑ The MTTP charge controllers and inverters are not designed to FCC Part 15(B), Class B standards, to reduce EMI/RFI.
- ❑ These smaller system produce hash and noise on the HF bands.
- ❑ Advantages:
 - ✓ Great for remote locations
 - ✓ Easy to install and setup
- ❑ Disadvantages:
 - ✓ If you are a ham radio operator these systems produce EMI and RFI

Future Considerations

- ❑ Replace the Lead Acid batteries with LiFePO4 – probably in the order of 700 to 800 AHrs
 - ✓ Due to additional load
 - ✓ Easy to add more batteries if required (use of battery stands)
 - ✓ Eliminate the need for regular generator usage during the winter
- ❑ Add about 4 more panels to the existing array.
- ❑ Build an insulated “Solar Shack” to keep the lithium batteries above freezing.

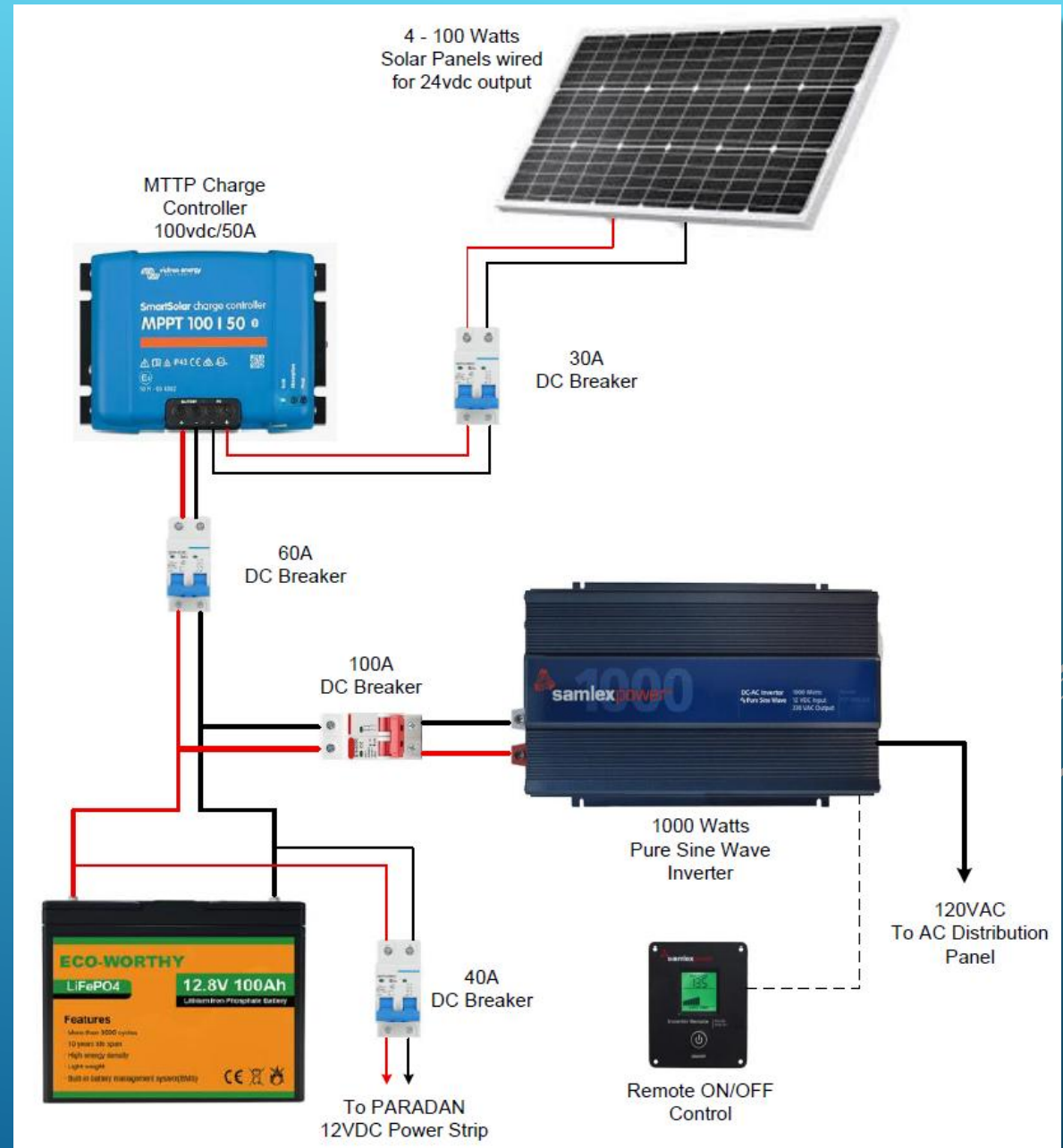


What would your Ham Shack look like on Solar Power ?



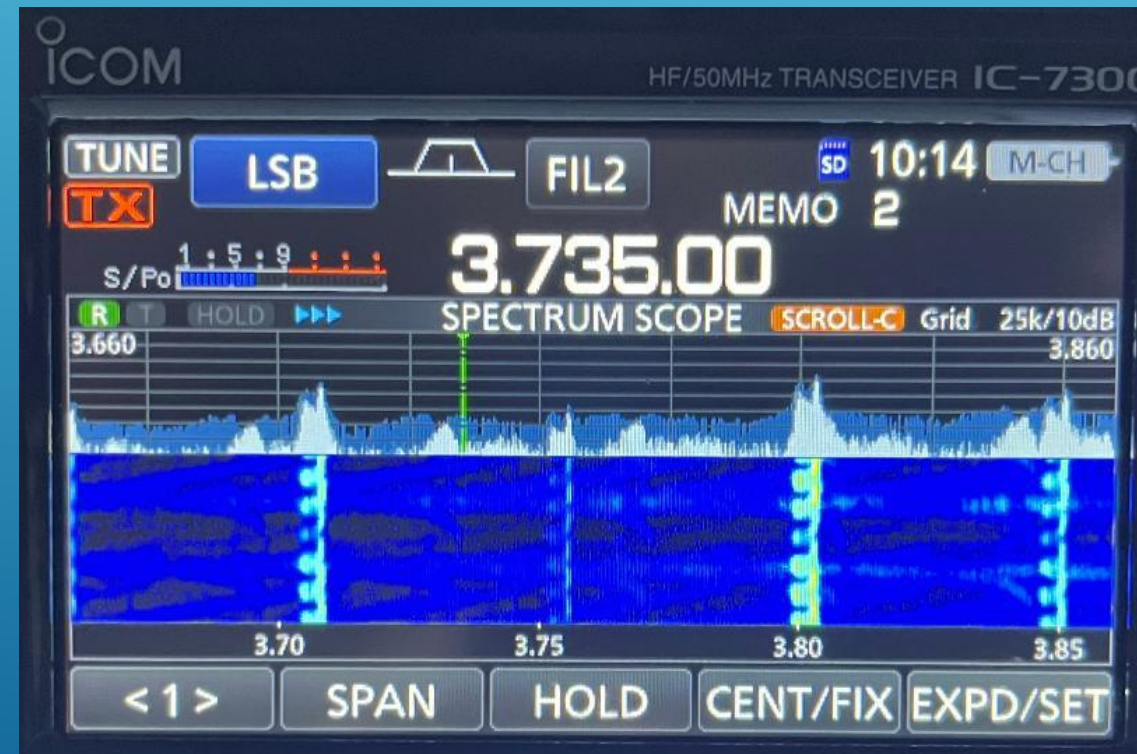
System Overview

- ❑ My present solar power setup for amateur radio.
- ❑ A Victron MTTP controller with a maximum input DC voltage of 100V and a maximum 50 Amps output.
- ❑ The Victron MTTP controller does not produce noise or hash on the HF bands.
- ❑ DC breakers are installed for protection and isolation.
- ❑ The Eco Worthy battery has its own internal BMS protection.
- ❑ The Victron and the Eco Worthy LiFePO4 battery can communicate via Bluetooth.

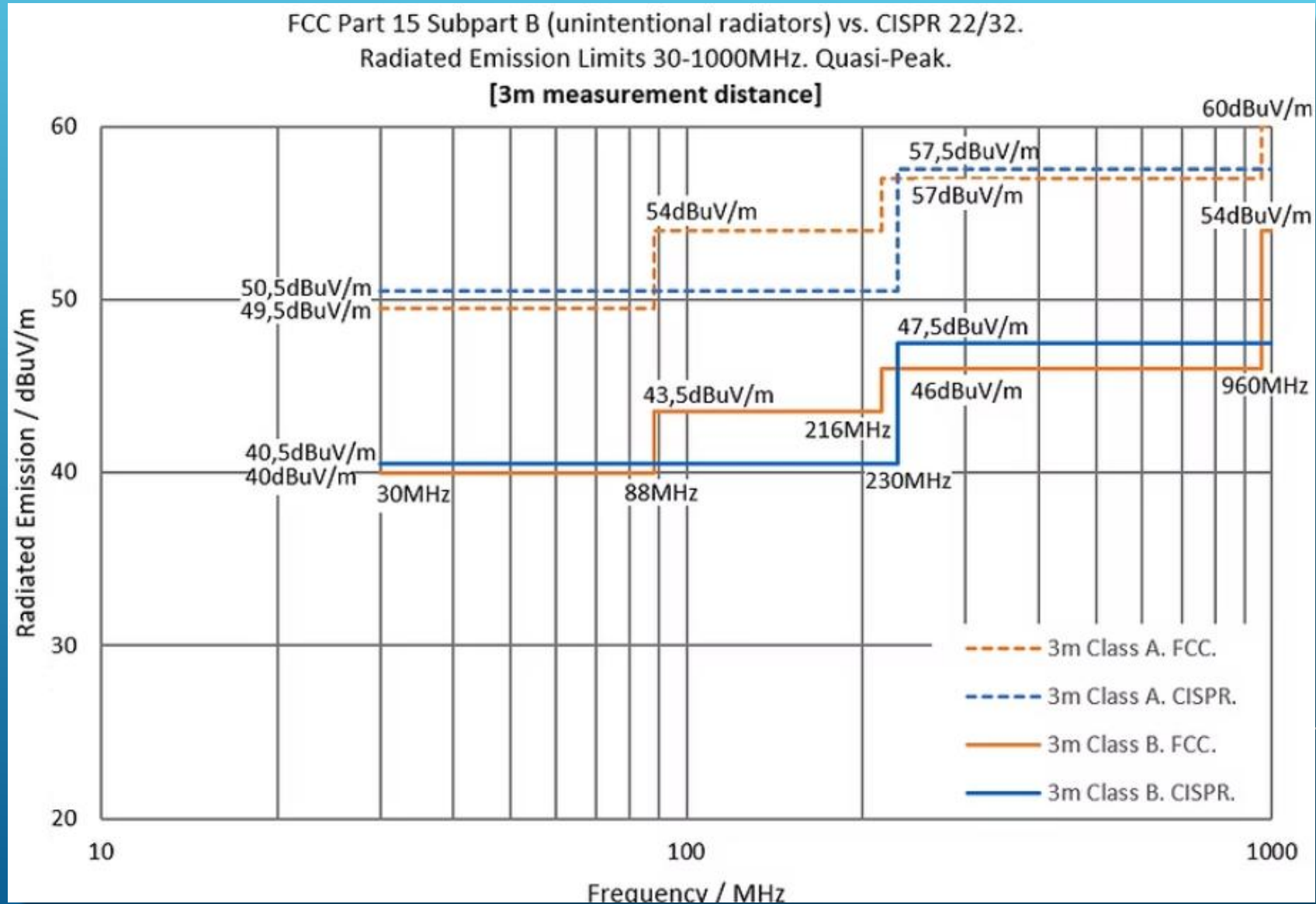


Inverter Operation

- ❑ Inverter is a SAMLEX SSW-1000-12A
- ❑ The left picture: Inverter OFF
- ❑ The right picture: Inverter ON – You don't want this on your HF radio
- ❑ This inverter does not comply with FCC Part 15(B), Class B or Class A



FCC vs IEC Radiated Emission Limits



Results and Observations

- ❑ There are good low noise solar power systems available for amateur radio operators.
- ❑ If you want to eliminate noise and hash on the HF bands, don't buy cheap equipment.
- ❑ When purchasing solar equipment, in particular Charge Controllers and Inverters, always be aware of their EMI/RFI emissions design specifications. They should comply with FCC Part 15, Class B specifications or IEC-61000-6-1, IEC-61000-6-2, IEC-61000-6-3, and EN 55032 (CISPR 35)
- ❑ Presently I run half my shack on solar power. Plans include a better inverter, more batteries and additional solar panels.
- ❑ With today's systems, you can start out with a modest system and build on it.

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ANY QUESTIONS



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