Portable Operation with Solar Power

Mark Breakey

KB7RHI

How Do Solar Panels Work

- The front of the panel has an excess of electrons and the back of the panel has a number of “holes” that are ready to receive electrons
- The photons from the sun strike the surface of the panel, dislodging electrons
- The dislodged electrons then travel from the front of the panel through the “circuit” and return to the other side of the solar panel

How Are Solar Panels Rated?

- Solar panels are rated using **STC** or “Standard Test Conditions”
- The solar manufacturer puts the solar panels in a flash tester at the factory that delivers 1000 watts per square meter of sunlight intensity (irradiance)
- The testing area holds the temperature at 25 degrees Celsius (77 F)
- They assume an air mass of 1.5
- The flash test gives the manufacturer their STC ratings on the panel
- Consider this like EPA mileage on the car you buy, your mileage may vary

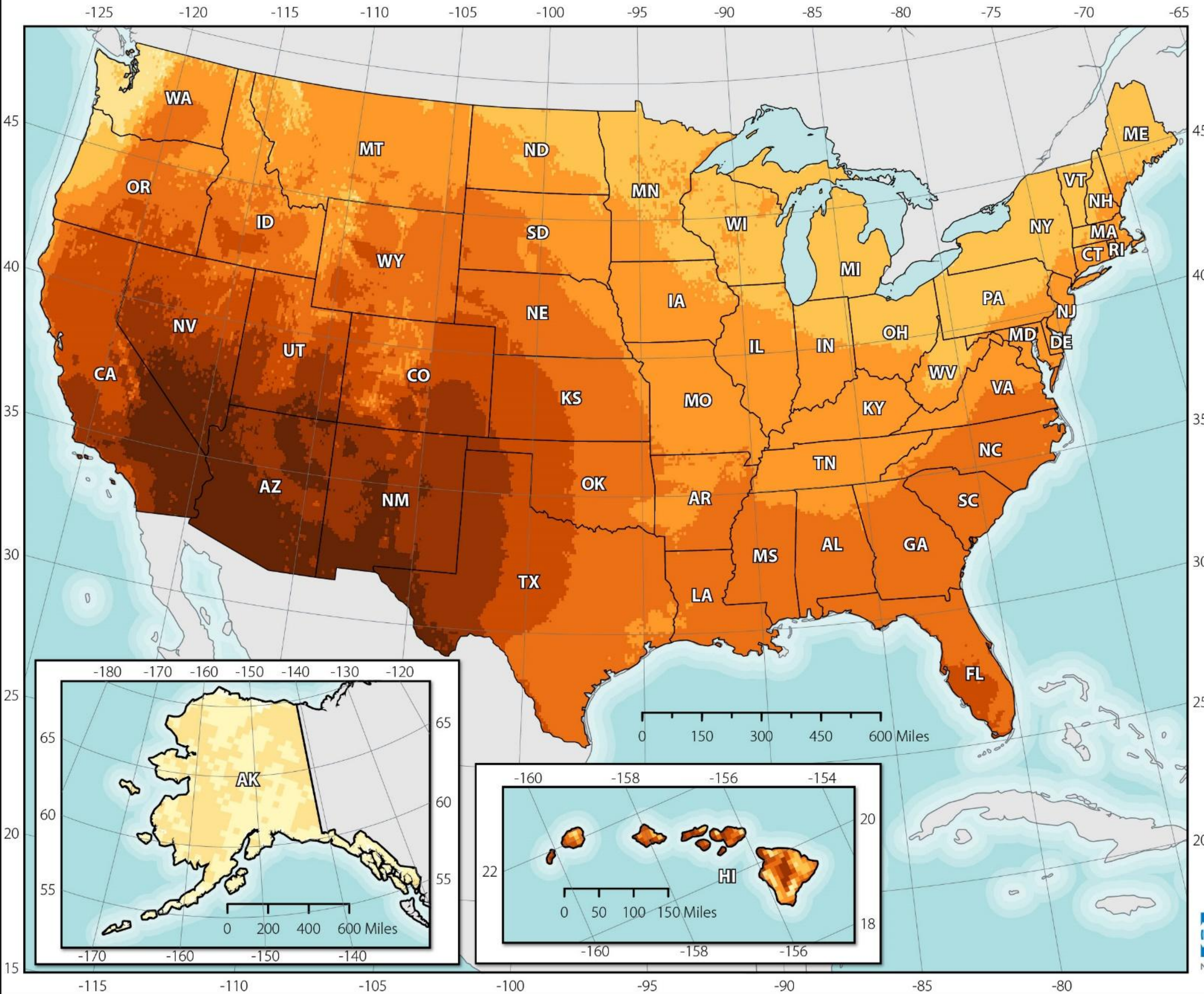
Irradiance In Watts Per Square Meter

- Back in the 1970s, a benchmark sunlight intensity (irradiance) was selected for STC ratings on solar panels
- 1000 watts per square meter was to represent the amount of sunlight energy striking a mid latitude location in the US at sea level on a clear day
- This is about the best conditions you will find in real life, often your sunlight intensity may be closer to 800 watts of energy per square meter
- A one meter square solar panel at 25% efficiency can produce 250 watts of energy

Sun Hour

- “Sun hour” – if we collected all the sun energy in a bucket from 30 minutes before noon to 30 minutes after noon, we would have one “sun hour” of energy
- Assume the sun energy around noon is 1000 watts per square meter, (clear summer day)
- One sun hour is equal to one kilowatt-hour
- In solar power, instead of saying how many kilowatt-hours per square meter per day, it is easier just to say how many “sun hours/day”

Photovoltaic Solar Resource of the United States



kWh/m²/Day

- > 6.5
- 6.0 to 6.5
- 5.5 to 6.0
- 5.0 to 5.5
- 4.5 to 5.0
- 4.0 to 4.5
- 3.5 to 4.0
- 3.0 to 3.5
- < 3.0

Annual average solar resource data are shown for a tilt = latitude collector. The data for Hawaii and the 48 contiguous states are a 10km satellite modeled dataset (SUNY/NREL, 2007) representing data from 1998-2009.

The data for Alaska are a 40 km dataset produced by the Climatological Solar Radiation Model (NREL, 2003).

This map was produced by the National Renewable Energy Laboratory for the U.S. Department of Energy.
Billy J. Roberts
19 September 2012

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

How Hot Do Solar Panels Get In The Sun?

- The STC used to test your panel was 25 degrees C
- As a solar panel gets hotter, the voltage will drop
- Your solar panel temperature will probably be about 20 degrees C higher than the ambient temperature
  - 95 degree (35 C) day, take 35C + 20 C and you have 55 C solar cell temperature, that is **30 C above the STC of 25 C**
- Solar panel output drops about .48% per degree C above 25 C in crystalline panels, (30 x .48 = 14.4) that is 14.4% less output on a 95 F day
- Thin film panels drop about half that

Sun Angle Intensity

- The angle to the sun does make a difference
- Lets say you have a sunbeam a mile wide hitting the earth from directly over head
- Then you have another sunbeam a mile wide that is shining on the earth from a 30 degree angle above the horizon
- The sunbeam falling from overhead covers a mile wide area
- The sunbeam coming in at the 30 degree angle above the horizon, covers twice as much area so is half as intense
- Would recommend pointing the panel at the sun and then rotate the face about 30 degrees west, the sun will start at 30 degrees to the left of the panel, then be directly in front, and then travel 30 degrees to the right of the panel, then it is time move it again

SEA PAC 2015

SEA PAC

SEA PAC 2015

SEA PAC


STOP
JAY
KG7CXO

What does AM 1.5 Mean?

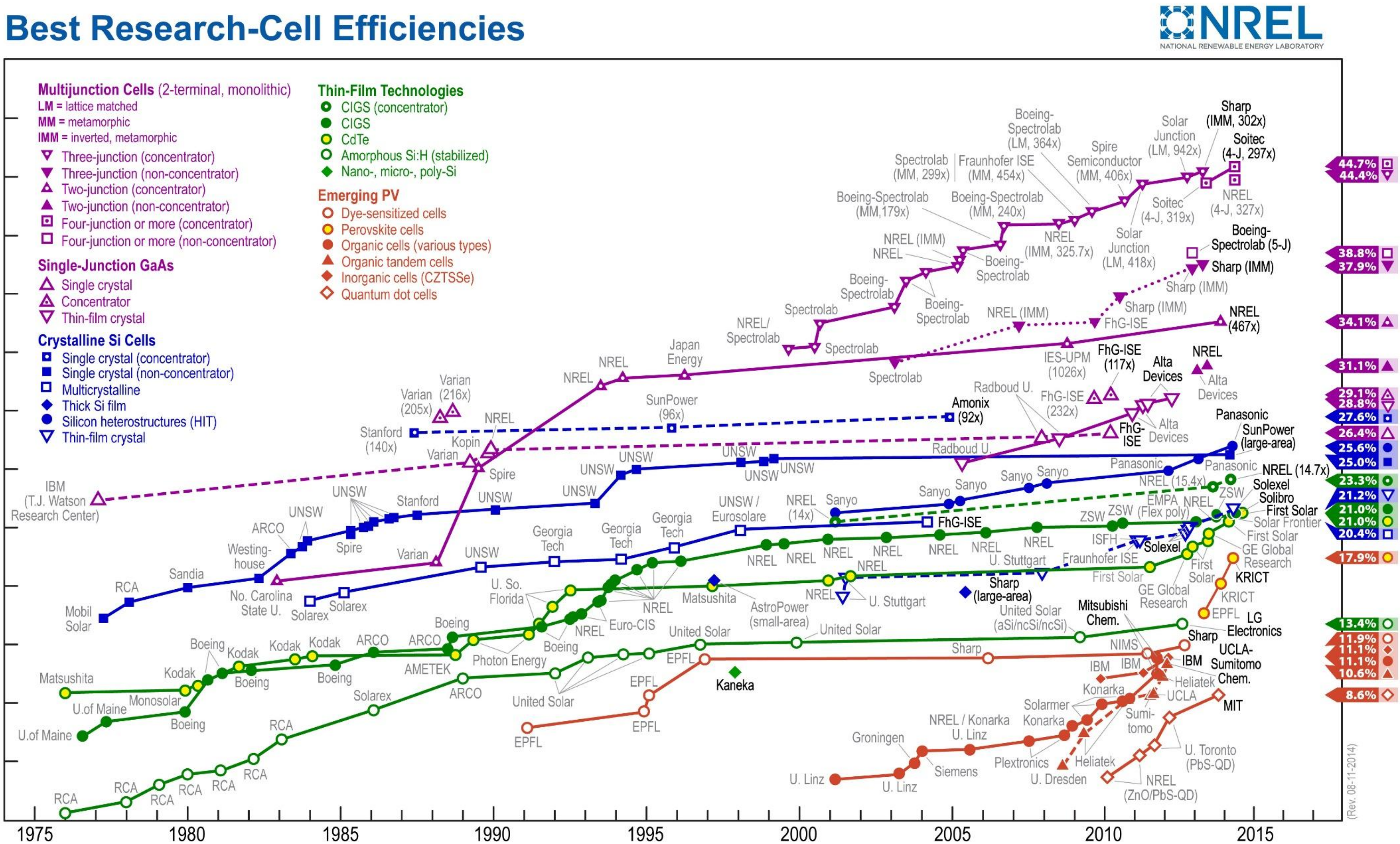
- "AM 1.5" on a solar panel spec sheet is talking about the air mass coefficient
- "AM 1.0" represents the air mass that a photon of light would travel through if you were at sea level and looking straight up and the sun was directly overhead (zenith angle)
- AM 1.5 (1.5 x atmosphere thickness) represents the amount of air mass that a photon of light would travel through if starting directly overhead (zenith), you dropped down about 48 degrees, as sunlight travels through more atmosphere thickness, you have some attenuation
- The panel takes into account the attenuation at 42 degrees above the horizon

Types of Solar Panels

- 1) Monocrystalline…best efficiency now about 25%
- 2) Polycrystalline…best efficiency now about 20%
- 3) Thin film…best efficiency now about 13%

- Latest technology, "think very expensive"
- Multi-junction (4 junction or more, non-concentrator) 38.8%
- Multi-junction (4 junction or more, concentrator) 44.7%

- Note…2015 data



Best Research-Cell Efficiencies
NREL
NATIONAL RENEWABLE ENERGY LABORATORY
Multijunction Cells (2-terminal, monolithic)
LM = lattice matched
MM = metamorphic
IMM = inverted, metamorphic
Three-junction (concentrator)
Three-junction (non-concentrator)
Two-junction (concentrator)
Two-junction (non-concentrator)
Four-junction or more (concentrator)
Four-junction or more (non-concentrator)
Single-Junction GaAs
Single crystal
Concentrator
Thin-film crystal
Crystalline Si Cells
Single crystal (concentrator)
Single crystal (non-concentrator)
Multicrystalline
Thick Si film
Silicon heterostructures (HIT)
Thin-film crystal
Thin-Film Technologies
CIGS (concentrator)
CIGS
CdTe
Amorphous Si:H (stabilized)
Nano-, micro-, poly-Si
Emerging PV
Dye-sensitized cells
Perovskite cells
Organic cells (various types)
Organic tandem cells
Inorganic cells (CZTSSe)
Quantum dot cells
Efficiency (%)
50
48
44
40
36
32
28
24
20
16
12
8
4
0
1975
1980
1985
1990
1995
2000
2005
2010
2015
44.7%
44.4%
38.8%
37.9%
34.1%
31.1%
29.1%
28.8%
27.6%
26.4%
25.6%
25.0%
23.3%
21.2%
21.0%
21.0%
20.4%
17.9%
13.4%
11.9%
11.1%
11.1%
10.6%
8.6%
(Rev. 08-11-2014)

Monocrystalline

- The solar "cells" are silicon material that is grown into a single crystal and then sliced
- These are the types that have the rounded off squares
- They are the most efficient and can have 20-25 year warranties, panels from the 1970s are still producing some power
- Like most panels, they do not tolerate **shading** or getting **dirty**, the power output drops a lot, just keep clean and in full sun
- Excellent choice for portable power
- They are the most efficient

Polycrystalline

- The material is melted and poured into a mold
- Slightly less efficient than the monocrystalline
- Good choice for portable operations
- Keep them in full sun and clean

Thin Film Solar Panel

- Low efficiency
- The roll up version, given your circumstances, may be best
- The Harbor Freight version is heavy and not very efficient
- The open circuit voltage is 15 volts, add in system Vdrop, and voltage this low could affect how much headroom you have above battery voltage for charging?
- Targeted for the “consumer market”, not a best choice for critical applications
- Thin film could degrade more quickly over time, the jury is out
- They do lose less power on warmer days, >25 C, about .25% per C, versus about 0.5% per C with crystalline panels

How To Combine More Than One Solar Panel

- If you have more than one 12 volt solar panel, connect them into a simple Anderson power pole distribution block
- Then connect one port to your charge controller
- Red-Dee-2 PS-4 connector
- Max voltage 58 VDC
- Max amperage 45 amps
- Max temp 80 C
- Min temp -20 C
- Accepts four Anderson Pole connections, no fuse

Solar Panel Watts

- Solar panel "talk" is about watts, we want to talk about amps
- Battery charging "talk" is about amp-hours
- Amps x volts = watts
- 50 watt solar panel working voltage is 17 volts and output is about 3 amps (17 x 3 = 51)
- When you hook up that 50 watt solar panel to your battery to charge, the working voltage **now** is the battery voltage of 12-15 volts
- 13 volts x 3 amps = 39 watts, in a battery system, you are interested in what the amperage is that the solar panel is providing

Charge Controller 3 Stage Charging

- You need a solar charge controller when charging batteries with a solar panel
- The nominal 12 volt solar panel working voltage output is about 17 volts, no controller and you would fry your battery
- “Bulk” charging is the first stage, this is where the solar panel output is passing into the battery, the battery voltage slowly rises to a peak voltage and then is held, peak voltage is about 14.2 volts on an AGM battery, this represents about half the charge time cycle and completes 80% of the state of charge
- “Absorption” is the second stage, the battery voltage is held at a constant peak voltage and the amperage is allowed taper as the battery is reaching a final charge, this is the final 20% SOC
- Third stage, the battery is fully charged and just a trickle charge is used to keep the battery topped off

Charge Controllers

- Be aware of the **peak voltage** that the charge controller sends to your battery, too high a voltage will kill your battery life, noted at the end of the bulk stage of charging
- When connecting a charge controller to your solar panel and battery, connect the charge controller to the battery leads first, then connect the solar panel leads, do the reverse when you shut down, this prevents a voltage spike going to the charge controller. The battery connected to the charge controller first will clamp the voltage inside the charge controller
- Morningstar 12v SunGuard 4.5 amp, works for up to 75 watts
- Morningstar 12v ProStar 30M is great for a small solar array, can parallel up to 300 watts, used at repeater sites alot

Types of Charge Controllers

- **P**ulse **W**idth **M**odulation…**PWM**, uses pulses to charge the battery, operates at battery voltage, best in warm conditions and with array wattage under 200W
- Simple On/Off…cut in and cut out type(Cheap)
- **M**aximum **P**ower **P**oint **T**racking…**MPPT**…tend to produce RF interference, can take the higher solar panel differential voltage above the battery voltage and convert to more amps when battery is low or in cold conditions

Charge Controller With Power Supply?

- Ham radio operators are very creative when it comes to using equipment, however, note the following
- Many charge controllers can stop the flow of charge to the battery by simple creating a short circuit with the panel and that does not have any negative effect on the solar panel
- Do not use a charge controller to control charging of your battery with a power supply, you could “Crowbar” your power supply

Solar Panel Specs (IV Curve)

- Voc = Max open circuit voltage(20-23v with 12 v panel), **no amperage flowing**, with your Volt Ohm Meter (VOM) on the Volts DC setting, check the voltage across the your sun facing panel, there is no load
- Vmp = Max **voltage** the panel can **produce, working voltage**
- Isc = Max short circuit current, **no voltage is flowing, test amps with VOM across panel terminals**
- Imp = Max power **amperage** the panel will **produce**
- Temperature coefficient Pmax = % power loss per degree C above 25 degrees C, IE "-0.48% per degree C", means the panel will lose 0.48% of its power for every degree above 25 C the solar panel heats up, panel temp is ~20 C > ambient temp

SEA PAC 2015

SEA PAC

Anderson PP Connectors

- Solar Panel>>>Charge Controller>>>Inline Meter>>>Distribution Box
- Recommend a distribution box with fuses
- Sarotoga boxes with fuses are no longer made, they work great…find a box/block that has Anderson PP and a fuse(s)
- PP 15 – 15 amp under load, AWG = #16 to #20
- PP 30 – 30 amp under load, AWG = #12 to #16
- PP 45 – 30 amp under load, AWG = #10 to #14
- Available at www.dcpwr.com

Demonstration Time

- How to connect a charge controller
- What happens when I try to charge a dead battery
- Voc (Open Circuit Voltage)…usually around 20-23 volts, tells how hot a panel is, will work better in cloudy conditions
- Isc (Short Circuit Amperage)…no voltage flowing, note shading effects on the panel and sun angle amperage, turn the panel away from the sun when connecting and disconnecting
- 12 volt fan operates with back scatter light
- Look at 3 different inline power meters and how they display in sunlight
- Parallel two batteries
- Note pre and post charge controller power with inline meter, see bulk charge stage cross over to absorption charge stage

SEA PAC 2015

SEA PAC


SCS
AT-100Pro Autotuner
LDG
YAESU

SEA PAC 2015

SEA PAC

SEA PAC 2015

SEA PAC

SEA PAC 2015

SEA PAC

SEA PAC 2015

SEA PAC

SEA PAC 2015

SEA PAC

SEA PAC 2015

SEA PAC

Portable Operation Basic Questions

- What are the power requirements of your equipment?
- How do I minimize voltage drop in my system?
- How much power am I using?
- What size and type battery should I get?
- What size and type solar panel should I get?
- Why did my radio just shut off when I keyed the radio?
- Does it make a difference how fast I charge/discharge my battery?
- What is the best way to charge my battery when it is raining?

Your Radio

- Try to keep your radio from overheating
- If you are outside, try to keep the radio out of direct sunlight, no pop up shelter, use some type of reflective shield well above the radio
- Allow good ventilation around the radio…flip the mounting bracket and use as a base
- Watch out for dust when outside, I had some dust at the Oregon Star Party 2014 that did cause some problems with my Yaesu FT-897 after one week of outdoor use, cleared the dust and had to do a hard reset of the radio
- Provide the proper supply voltage

Radio Voltage Needs

- Most of our radios require 13.8 volts +/- 15%
- That is 11.73 volts to 15.87 volts (13.8v +/- 2.07 volts)
- Our battery voltage when its full is about 12.7 volts
- Do not include the “surface charge”
- That means we have a 1.0 volt “window” that we have to use wisely, or our radio might not work properly or even just shut off
- 11.7 volts to 12.7 volts is our “window”
- Think of 11.7 volts as our “cutoff” voltage
- Of Note…Battery voltage < 10.5 volts will cause significant sulfation

Battery Voltage As A **S**tate **O**f **C**harge

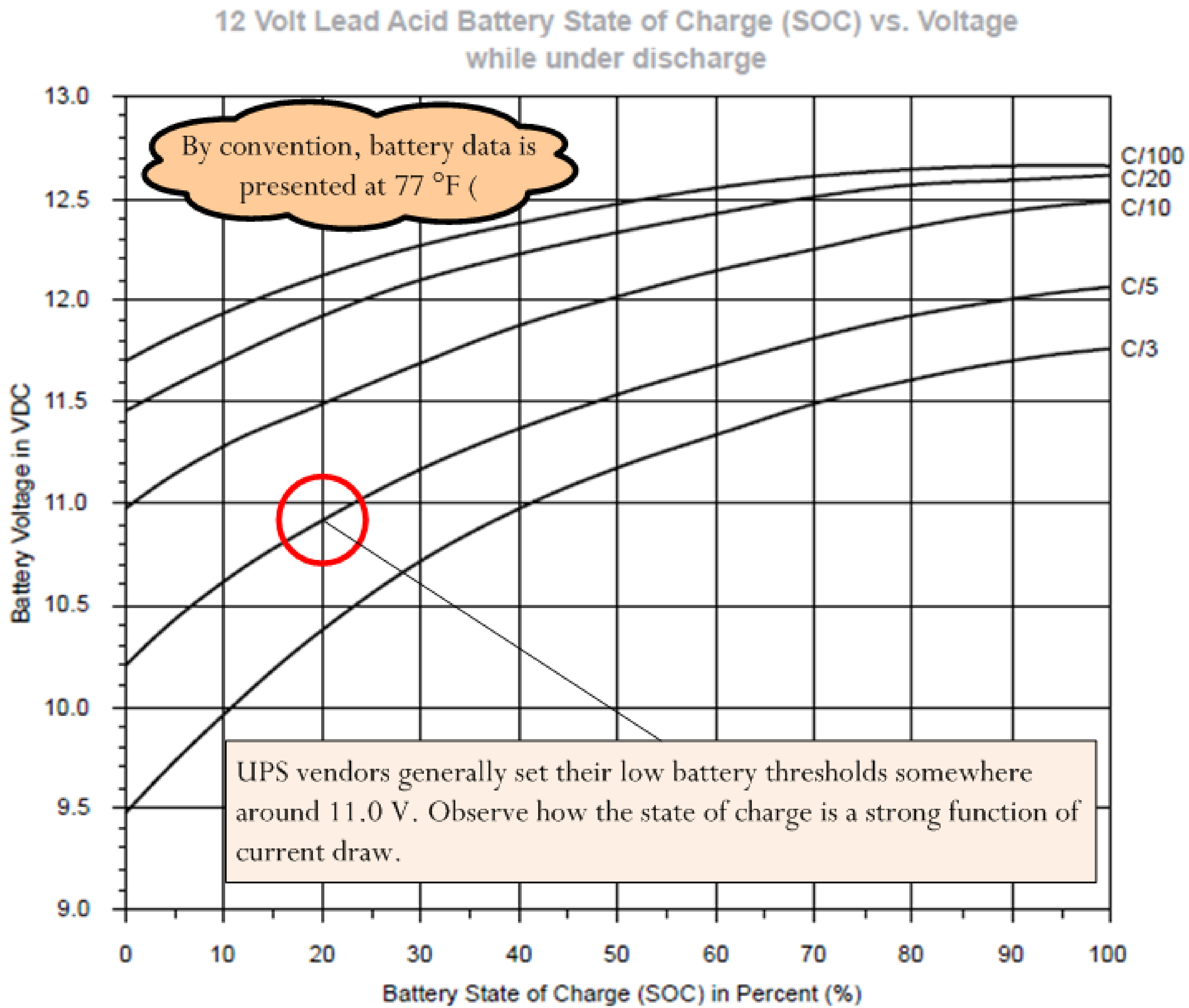
- 12.6v or more 100%
- 12.4v 75%
- 12.2v 50%
- 12.0v 25%
- 11.7v 0%
- Lead-acid battery at 77 degrees F and the battery has been at **rest** for 2-4 hours, not a surface charge
- **Note that every 0.2v drop is equal to a 25% loss in effective battery capacity**
- (Note) Battery voltage **SOC** is not that accurate

SEA PAC 2015

SEA PAC

Battery Voltage Sag

- A battery at even full charge will have a voltage sag the moment it is placed under load
- The higher the load, the more voltage sag
- The voltage then slowly drops over time as the battery is in use
- If your radio can no longer transmit at full power, reducing power will allow more transmit time in the field
- Find your battery’s spec sheet called “discharge characteristics”, it shows the voltage over time with different loads
- http://datasheet.octopart.com/LC-X1228AP-Panasonic-datasheet-9783856.pdf scroll down to the “Discharge characteristics” graph


12 Volt Lead Acid Battery State of Charge (SOC) vs. Voltage
while under discharge
By convention, battery data is presented at 77 °F (
UPS vendors generally set their low battery thresholds somewhere around 11.0 V. Observe how the state of charge is a strong function of current draw.
C/100
C/20
C/10
C/5
C/3
Battery Voltage in VDC
13.0
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
0
10
20
30
40
50
60
70
80
90
100
Battery State of Charge (SOC) in Percent (%)

Getting The Power From Your Battery Only System To Your Radio

- The best size wire is 10 gauge(AWG) stranded wire
- You will see 12 gauge and 14 gauge wire used, this is too small due to the voltage drop at 12 volts, always try to use 10 AWG wire 10’ run of 14 AWG wire at **8 amp load** = Vdrop of 0.4 volts
- 10’ run of 10 AWG wire at **8 amp load** = Vdrop of 0.18 volts
- Yaesu FT-7900 FM radio on high power (50 watts RF) uses 8 amps
- 0.4 VDC Vdrop is equal to losing 50% of my effective battery capacity! You want to minimize the Vdrop. Once the voltage goes below 11.7 volts, my radio might not work right and even shut down
- Remember, every 0.2 volts of voltage drop I loose in the power cable = about 25% of my total effective battery capacity

HF Radio Cable Voltage Vdrop

- Remember…voltage sag + voltage drop should not go below 11.7v with many radios
- Voltage at power supply/battery = **12.5 volts**
- Calculating the voltage drop
- Battery power cable is **#14g wire** and 6 feet long with a load of 22 amps, **v-drop = 0.66v**
- Battery power cable is **#12g wire** and 6 feet long with a load of 22 amps, **v-drop = 0.42v**
- Battery power cable is **#10g wire** and 6 feet long with a load of 22 amps, **v-drop = 0.29v**

Voltage Drop Calculations

- Find a good site on the web to see what your voltage drop is for your station
- http://www.currentsolutions.com/vdrop.php
- http://www.calculator.net/voltage-drop-calculator.html

- Typical mobile radio loads are:
- 10-12 amp load should provide about 50 watts of FM power
- 6.5 amp load should provide about 25 watts of FM power
- 5 amp load should provide about 10-20 watts of FM power

Cable Voltage Drop Example

- Current Solutions example
- Enter your power supply/battery voltage______
- Enter your load in amps______
- Enter your total wire run in feet______ (this includes the length of your red wire and your black wire)
- Enter your wire size in American Wire Gauge size AWG________

How Much Power Are You Using?

- Strongly recommend you get a DC inline power meter
- **Watts Up**, easy to read outside in daylight, display is not lighted
- **Powerwerx**, not as easy to read in daylight, display is lighted
- **Turnigy 130A,** easy to read outside in daylight, lighted display, available at Hobby King, you put on the power pole connectors, order from the USA West warehouse, priced cheaper than the Watts Up and Powerwerx
- The Turnigy is not quite as accurate per some reviews

Inline Meter Screen Display

- Continuously displays Amps, Volts and Watts
- Sequentially displays every second the following:
- Amp-hours (Charge) display = Ah (charge/discharge info)
- Watt-hours (Energy) display = Wh
- Peak Amps (Current) display = Ap (sizing battery info)
- Minimum Volts display = Vm (voltage sag, >11.7v?)
- Peak Watts (Power) display = Wp (think solar power)
- The above is for the Powerwerx meter which has a lighted display for outdoor bright light and for at night
- Turnigy meter with >1 amp load will include time display of hours/minutes/seconds of operation

Inline Meter Use

- Current is measured from **source** to **load**, drawing current in reverse will damage the meter
- When you connect your radio to the battery, the battery is the **source** and the radio is the **load**, the current travels from the battery to the radio
- When you connect your solar panel to the battery, the solar panel is the **source** and the battery is the **load**
- **Battery(source)>>>>>Meter>>>>>Radio(Load)**
- **Solar Panel(Source)>>>>>Meter>>>>>Battery(Load)**
- **Note which direction the current will travel**

Inline Meter…Solar Panel To Battery

- Solar panel>>>>charge controller>>>>**meter**>>>>battery
- “Amp-hours” will show the charge that your battery has received from the solar panel
- Current in “amps” is displayed that is going to your battery
- The “voltage” display represents your battery voltage
- “Minimum Volts” would show the lowest drop in voltage your battery went to during transmit, the voltage is not directional like amps is
- How many “watts” is my panel really providing right now

Inline Meter…Battery To Radio

- Battery>>>>**meter**>>>>distribution block>>>>radio
- "Volts" shows your battery voltage
- "Volts minimum" will show the minimum voltage sag during a transmit cycle
- "Amps" will show the radio current, useful for seeing the current draw at different radio power settings
- "Amp-hours" will show Ah of charge/discharge

Rated Capacity Of Your Battery

- Lead acid batteries are often rated by a certain number of amp hours over a rated discharge time
- Amp-Hour (Ah) = if you have a constant load of one amp for a period of one hour, that is 1 Ah(3600 Coulombs)
- 10Ah = 1 amp load for 10 hours or 5 amps for 2 hours
- Example…100 Ah battery with 20 hour rating.
- How many Amp Hours you will get depends on the load, ambient temperature, age of your battery and your state of charge

Battery Discharge Characteristics

- Battery discharge is not linear, (Peukert's law describes the real story)
- 100 Ah battery with 20 hour rating means the battery should be able to provide a 5 amp **constant load** for 20 hours, the voltage at the end of time period **under load** should be 10.5v, (this voltage is too low for most of our radios, and we do not want to ever discharge a battery that far, unless no other choice)
- **If the battery is discharged in a shorter time, with a higher current, the delivered capacity is less**
- **Best practice, limit your transmit amps (peak current) to your battery Ah x .2(20%), IE 28Ah x .2 = 5.6 amps max**

Mobile Radio Amp-Hour Calcs

- How to calculate your average amp-hour discharge rate
- Tx amps x % time + Rx amps x % time = average amp load
- **Tx-amps** is **5 amps** x Tx **time 10%/hr** , so 5 x .1 = .5Ah (~20 watts)
- **Rx-amps** is **.3 amps** x **Rx time 90%/hr,** .3 x .90 = .27Ah
- Tx .5Ah + Rx .27Ah = **.77** average amp load over the hour
- So if you transmit 10% of the time and receive 90% of time in one hour, you have a discharge of .77Ah
- This is transmitting 6 minutes every hour and listening 54 minutes every hour, at this rate, 10 people per hour could be sharing information on the frequency and an unlimited amount of people listening, all would receive the information
- Represents 1 of 10 people talking on an active circuit

Yaesu FT-7900 Ah Discharge Chart

Minutes	Low	Mid2	Mid1	High
Tx 5m/Rx 55m	0.46Ah	0.52Ah	0.61Ah	0.92Ah
Tx 10m/Rx 50m	0.64Ah	0.76Ah	0.94Ah	1.56Ah
Tx 15m/Rx 45m	0.80Ah	0.99Ah	1.26Ah	2.19Ah
Tx 20m/Rx 40m	0.98Ah	1.23Ah	1.59Ah	2.83Ah
Tx 25m/Rx 35m	1.15Ah	1.46Ah	1.91Ah	3.46Ah
30 min Tx/Hour	1.32Ah	1.7Ah	2.24Ah	4.10Ah
Rx amps	0.3 amps	0.3 amps	0.3 amps	0.3 amps
Tx amps	2.36 amps	3.11 amps	4.19 amps	7.9 amps
Min Batt Size	12Ah	16Ah	21Ah	40Ah
Power setting	5 W	10 W	20 W	50 W

18Ah Battery With An HT

- Yaesu Vx5r triband HT being used on 2 meters
- Duty cycle is Rx 90% and Tx 10% per hour
- Rx (battery saver mode) = 55mA
- Tx 5 watts on 2 meters = 1.6 amps
- Rx 0.055 amps x 90% = 0.04 amp
- Tx 1.6 amps x 10% = 0.16 amp
- Average Load = 0.2 amp
- 9Ah total divided by the 0.2 Ah = 45 hours of operation est.
- Constant load rating = 0.9amps(18Ah/20 hours = 0.9amp constant load was used to obtain the 18Ah rating, you are staying under the rated discharge current

Duration Of Operation On A Battery

- Duration of operation depends a lot on what your average amperage draw on the battery is and on what your Ap (peak amperage) is during your operation
- Transmit 10% of the time using 5 amps
- Receive 90% of the time using 0.3 amps
- 5 x .1 = 0.5 and 0.3 x .9 = 0.27, (0.5 + 0.27 = 0.77Ah)
- Use a 28 Ah battery, top 50% or 14Ah
- 14Ah/0.77Ah = 18 hours of operation
- Note that this example of .77 average amps is less than the battery 28Ah/20hour rate of 1.4 amps constant load
- Plan on a much shorter operating time with average amps > than the battery rating average amps

Lead Acid Battery Ah Thoughts

- Note the battery discharge amperage used in the 20 hour rating calculation
- For example, the 100 Ah battery with a 20 hour rating would have a constant discharge rate of 5 amps/hour x 20 hours
- This Ah rating was made with a constant load of 5 amps, if your average load amps exceeds this rate, your effective battery Ah will probably be less
- Do some practice in the field with your inline DC power meter and log your results

Rule Of Thumb-Lead Acid Battery

- **Recommend just using no more than 50% of battery rated Ah and cap the load at 20% of battery rated Ah**
- Example…28Ah x .5 (50%) = 14Ah available for your operations
- Think of this as how much energy you have in the battery bucket, assuming a fully charged, newer battery, and not cold
- Next, try to limit peak amps to 28Ah x .2 (20%)= 5.6 amps

Rechargeable Batteries

- Li-Ion 150 Wh/Kg 2-3 yrs life if never used
- Ni-Mh 100 Wh/Kg Self discharge of 30%/month
- Ni-Cd 60 Wh/Kg Memory issues, low charge efficiency
- Lead-Acid 25 Wh/Kg High charge efficiency

Construction Of Lead Acid Batteries

- 1) Starter battery
- 2) Marine Battery
- 3) Deep Cycle Battery
- The batteries differ mainly due to the thickness and number of “plates” used inside each cell, six cells for a 12 volt battery
- The deeper you discharge a battery, the more the “plates” want to bend and flex

SEA PAC 2015

Starter Battery

- These are the batteries you find in cars and riding lawn mowers
- They have many thin “plates” which allow a lot of amperage draw, but only over a short period of time
- They should not be discharged more than 20% or they will be damaged
- For portable operation, these are a last resort
- This is a battery that I would use during an emergency, but **not** a battery that I would **buy** to **prepare** for an emergency

Marine Battery

- The battery “plates” are thin enough to start a boat engine
- The battery “plates” are thick enough to have a greater depth of discharge than a starter battery
- These are a hybrid battery, not a true deep cycle battery
- This is a compromise battery for our purposes
- I would still use one if available during an emergency

Deep Cycle Battery

- These batteries have the thickest plates
- DOD – Depth Of Discharge can be as low as 80%
- They are not designed to provide as much amperage for say starting an engine
- The deep cycle battery has lower “cranking amps”
- It is recommended that you only discharge your deep cycle batteries down to 50% and no more

3) Types Of Deep Cycle Batteries

- 1) **FLOODED**
- 2) **GEL CELL**
- 3) **AGM (absorbed glass mat)**

Flooded Lead-Acid Battery

- Requires a higher charge “top off” voltage and also needs an equalization charge about every 30 days or so due to stratification if in constant use
- Filled with 65% distilled water and 35% sulfuric acid
- Can spill acid if tipped, use ammonia to neutralize
- Cheaper to buy, but more maintenance issues, they gas while charging and need water replacement from time to time
- OK, but not recommended

Gel Cell Batteries

- Very sensitive to overcharge
- Needs a lower charge “top off” voltage and in fact, many chargers will slightly over charge these batteries and they will dry out sooner than normal
- Recombination of gases during charging occurs at a much slower rate because of the highly viscous electrolyte
- Charge too fast-- gas pockets will form on the plates and force the gel electrolyte away from the plate, decreasing capacity
- If we are given one, ok, would not buy new

AGM Batteries

- Best **Lead Acid** battery for **portable** operation
- Term to know, **C** = Battery capacity in amp/hours
- AGM can be charged at a C/3 rate, more commonly C/10 to C/20, would recommend no higher than C/5, the gasses will not recombine if charged too fast, temperature could rise too high
- AGMs not subject to stratification, but are subject to sulfation if not fully charged after use

Sizing Solar Panel, Battery & Radio

- AGM Battery charging amps, you can charge at 1/3 the Ah rating, but I would recommend about 1/5 the Ah rating
- 75 Watt panel provides about 4.5 amps in full sun, this would be ideal for charging a 22.5 Ah or greater size battery (4.5 x 5)
- 75 Watt panel should not be used to charge an AGM battery less than 13.5 Ah (4.5 x 3)
- Two popular batteries are the 18 Ah and 28 Ah
- Parallel the 18 Ah to get 36 Ah/5 = 7.2 amp load = will easily handle **medium power** on your mobile VHF/UHF radio
- Parallel the 28 Ah battery, get 56 Ah/5 = 11.2 amps = will handle **high power** on your mobile VHF/UHF radio

Battery Load Sizing

- I would recommend your max amps discharge load on a battery be no more than 1/5 of the total battery Ah capacity
- Radio Tx current in "**amps**" x **5** = total Ah of battery or more
- 100 Ah battery, load should not exceed 20 amps
- 50 Ah battery, load should not exceed 10 amps
- Portable VHF/UHF mobile radio at full power should have at least a ~50 Ah battery
- Portable HF radio at full power should have at least a ~100 Ah battery
- Typical VHF/UHF mobile radio at **10 watts** RF transmit power draws about 3.1 amps X 5 = **minimum 15.5 Ah battery**

Using More Than One Battery

- You can connect two batteries together of the same age and Ah rating
- Parallel connection is where you connect the positive to positive and negative to negative of your batteries
- Parallel connection will double your Ah and the voltage remains the same, the weaker battery might “loof” some
- Series connection is positive to negative and positive to negative of both batteries
- Series connection will double your voltage and you have the same Ah rating, both batteries will “work” at full efficiency

What Your Battery Wants You To Know

- **Constant Heat** kills batteries…you loose 50% capacity for every 15 degrees above 77 degrees F that your battery is continuously stored, could be an issue in your vehicle during summertime
- **Cold** just temporarily reduces available battery capacity, more capacity is chemically available once the battery temp rises
- Your battery needs to be charged up soon after you use it, while discharging, the positive and the negative plates build up sulfate, do not leave the sulfate to crystallize hard, charge it back up ☺

Things That Hurt Your Battery

- 1) Not fully recharging soon after you have used the battery, the sulfate coating on the plates can become hard and crystallize, (this is a repeat, but very important)
- 2) Allowing your back-up power battery to remain in your car during the summer in high heat
- 3) Discharging your battery too deeply, try to limit to 50% DOD (Depth Of Discharge)
- 4) Charging your battery without some type of controller, you will overshoot the voltage and fry your battery, risk thermal runaway
- 5) Do not mix different size and age batteries, parallel same size batteries

Things That Could Hurt You

- **Thermal runaway** is a condition in which the battery temperature increases rapidly resulting in extreme overheating of the battery
- This condition can only occur if the battery is at high ambient temps and/or the charging voltage is set too high
- As the battery accepts current, its internal temperature rises, the rise in temperature reduces the battery impedance, causing the battery to accept more current, the higher current further heats the battery and so on, causing the battery temperature to “runaway”
- An upper limit is reached and the **electrolyte** begins to boil away, once boiled away, the battery temp can climb further to the point of melt down and possible fire

Shorting The Battery Terminals

- A number of lead acid batteries have very low internal resistance and therefore are capable of delivering high currents if the battery terminals are shorted
- The heat resulting from a short circuit could cause severe burns and be a potential fire hazard
- Take precautions necessary to prevent accidentally placing objects across the terminals
- Always have a fuse between the battery and your equipment

Release Of Ignitable Gasses

- VRLA batteries produce **Hydrogen** and **Oxygen** while being charged
- VRLA batteries do not recombine 100% of the gasses, a small amount of hydrogen and oxygen are released from the pressure relief valve
- Do not store a flooded or VRLA battery in a sealed or airtight container, hydrogen can ignite at concentrations as low as 4%
- Hydrogen is a colorless, odorless gas. Human senses cannot detect it.
- Electrical energy in excess of what is needed for the chemical reaction, decomposes the water of the electrolyte into oxygen at the positive plates and hydrogen at the negative plates.

SEA PAC 2015

SEA PAC

Best Way To Charge My Battery When It Is Raining Outside

- Use a 110v smart charger, recommend the **Battery Tender Plus**
- You are interested in three stages of charge, “bulk”, “absorption” and “float”
- Battery Tender Plus will charge AGM batteries from 3.75Ah to 25Ah (C/3 to C/20), I use it for my 100Ah battery just fine
- They also make a model that puts out 5 amps designed for the 15Ah to 100Ah AGM battery, less likely to buy one, my 1.25 amp charger has worked great

Battery Tender Plus

- The Deltran Battery Tender Plus is the best charger I can recommend
- 1.25 amp charger that does temperature compensated “top off” voltage
- 3 stage charger
- Bulk = the first 80%, constant 1.25 amp charge with rising battery voltage, takes about **half** of the total charging time
- Absorption = **fixed voltage** and **tapering down amperage** for the top 20% charge, if not done, sulfation can occur
- Float charge, will provide some charge as needed to keep battery topped off
- This charger appears to be the most widely recommended in my literature search

Must Have Items For Portable Solar

- Battery, prefer AGM…need a fuse for safety in the circuit
- Inline power meter
- Solar panel
- Charge controller, like the Morningstar 12v SunGuard 4.5 amp
- Going digital, use a tablet like the HP Stream 8 loaded with RMS Express, the Powerwerx USBbuddy 12v to 5v converter, AboveTek AUT-39C USB meter, Dell Venue micro-USB to USB dongle(This dongle allows you to do USB charging of a tablet and send USB data)note…the dongle charge current is less than a direct connection to the micro-USB port on the tablet
- Get the GlobalSat BU-353S4 GPS, you can use to send position reports and an SMS message that is seen on APRS.FI

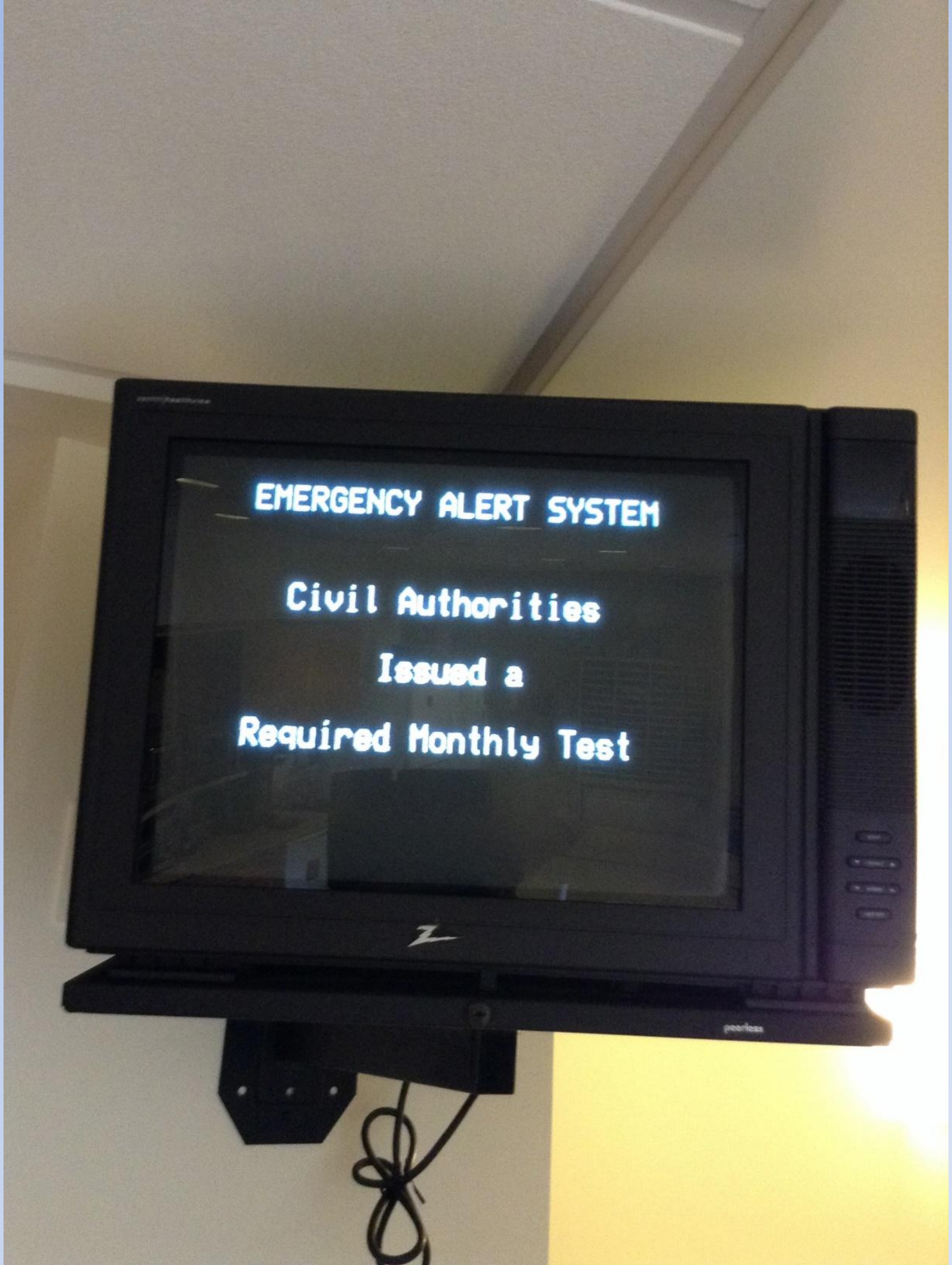
Oregon Star Party Sample Station

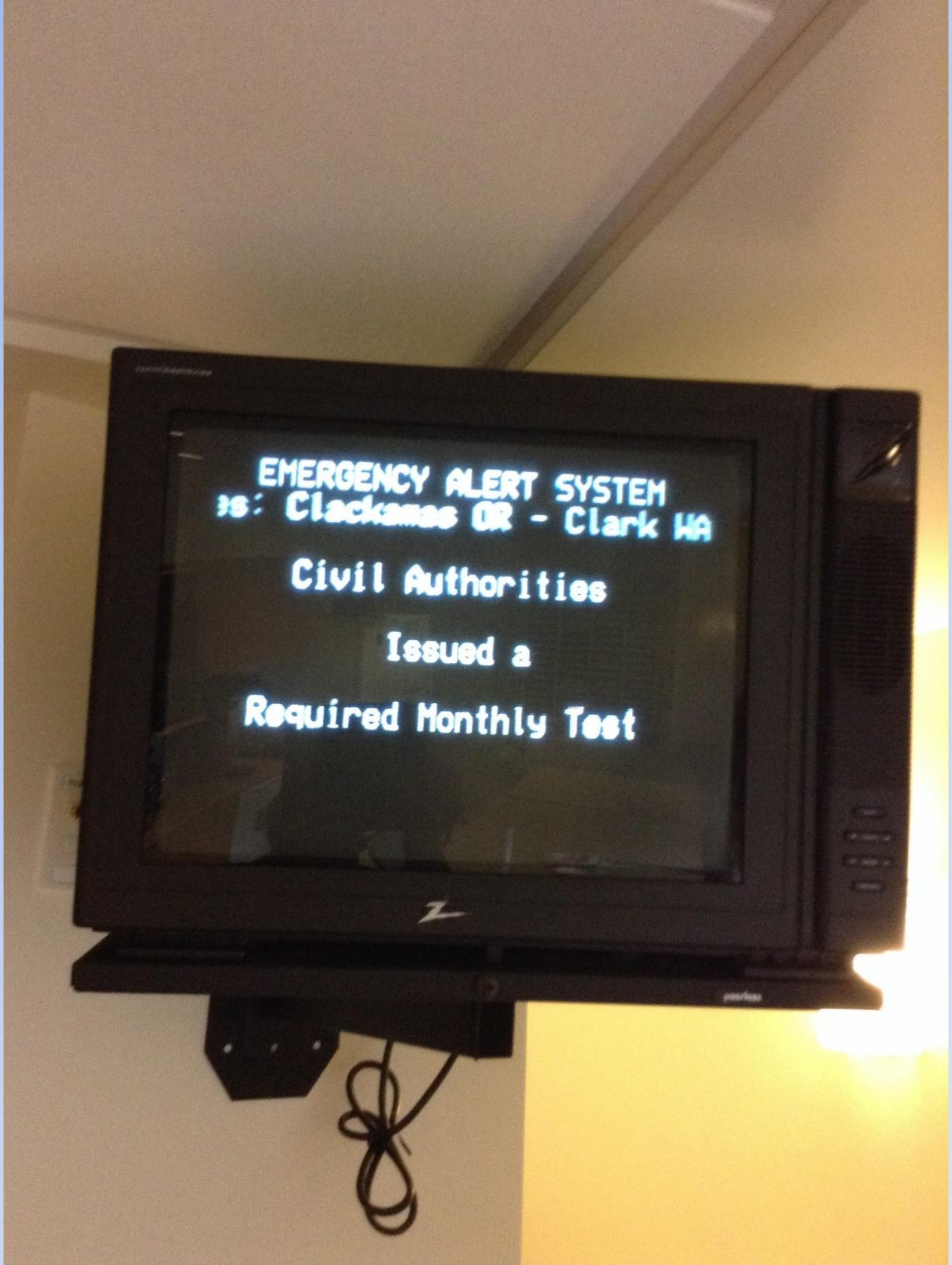
- Solar panel…65 watt, in full sun will provide about 3.6 amps
- Charge controller…Morningstar **S**un**G**uard, rated for 4.5 amps
- Battery…AGM 100 Ah/20 hour rating
- Yaesu FT-897 for voice and pactor 3 digital
- TNC SCS pactor modem
- Antenna…folded dipole TD-90 on Comet mast
- Laptop with 12 volt DC power converter

What A Tablet With Windows OS Can Do For You In The Field

- You can take several pictures at a site and use the picture size reduction feature on RMS Express to attach your selected pic size to a message
- Tablets have small size with longer battery life and less power consumption needs when running off batteries
- You can hand an agency person the tablet with RMS Express open and have them enter their message with a BT keyboard and BT mouse, then attach to your station and send the message via VHF/UHF Packet radio or HF Pactor/RP/WINMOR
- Attach a battery operated printer and print the message received for the IC
- Remember you can send email SMS to phone text messages


AIRMAX
Ecofan
HEAT POWERED
STOVE FAN
Increase Your Comfort!
Costs Nothing to Operate
Burn 18% Less Wood
175 CFM Warm
Air Circulation
Safe & Silent
Nickel blade
Caframo
The Leader in Heat Powered Technology


EMERGENCY ALERT SYSTEM
Civil Authorities
Issued a
Required Monthly Test


EMERGENCY ALERT SYSTEM
Clackamas OR - Clark WA
Civil Authorities
Issued a
Required Monthly Test