

DC Power Distribution, Batteries, and Solar

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W9WMR**

West Mountain Radio

DC Distribution

- Resistance, Power Loss
- Connectors and Switches
- Diagnosing Problems and Grounding Issues

Batteries

- Comparison of Lead-Acid and Lithium-ion technologies
- Battery Boosting
- Battery testing

Solar Power

- Solar Panel power characteristics
- Configurations for a UPS station

The Resistance Problem



50 feet, 12 AWG, 0.165 ohm cable, 0.08V loss, <1%



50 feet, 12 AWG, 0.165 ohm, 0.83V loss, 7%

Picking the Right Cable



Cable Size	Loss @ 5A Load	
	Volts	% of Power
8 AWG	0.31 V	3%
10 AWG	0.5 V	4%
12 AWG	0.79 V	7%
16 AWG	2.01 V	17%
18 AWG	3.19 V	27%
22 AWG	8.07 V	67%

Where does the lost energy go?





Calculators

Below is a list of on-line calculators from West Mountain Radio to assist you.

[Find Cable Size](#)

Find out what cable size you need depending upon the length and current draw.

[AGM / Gel Cell Battery Capacity Calculator](#)

Provides the recommended amp-hour rating of your back up battery. Based on the information you provide, it considers derating factors such as discharge rate, cycle, and run time relative to 20 hrs.

[Dipole](#)

[Double Bazooka NVIS](#)

[Double Extended Zepp NVIS](#)

Use one of the above three Antenna calculators to determine which antenna best fits at your location.

Find Cable Size

Fill out this form to find out what cable size you need.

*Length of Run: Feet

Voltage at Source: Volts

Current Draw: Amps OR Watts

[Find Cable Size](#)

Cable Size	Loss	
	Volts	% of Power
8 AWG	0.63 V	5%
10 AWG	1 V	8%
12 AWG	1.59 V	13%
16 AWG	4.02 V	32%
18 AWG	6.39 V	51%
22 AWG	12.6 V	100%

Connector Losses



0.000525 ohms
At 5A 0.013 W
At 40A 0.84 W



0.03 ohms
At 5A 0.75 W
At 40A 48 W



0.01 ohms
At 5A 0.25 W
At 40A 16 W



0.003 ohms
At 5A 0.075 W
At 40A 4.8 W



- **15A, 30A and 45A contacts interchangeable**
- **Genderless– Any connector plugs into any other**
- **Impossible to mate incorrectly**
- **Crimp – more effective and faster than soldering**
- **UV safe – but – NOT WATERPROOF**

Powerpole® is a registered trademark of Anderson Power Products, Inc.

Beware of Switch Currents

3A DC



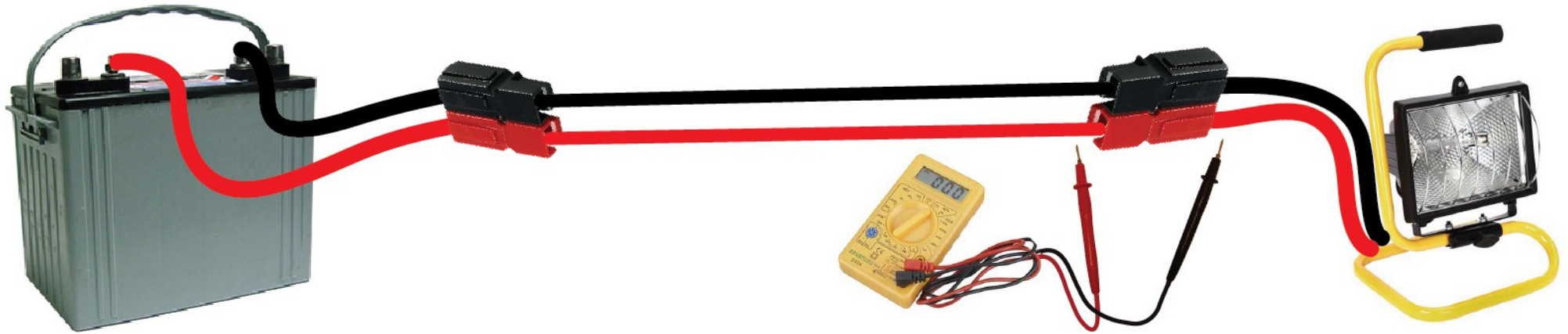
100A DC



15A DC



Diagnosing Problems



0.05V drop @ 20A = 1W loss

0.1V drop @ 20A = 2W loss

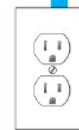
0.5V drop @ 20A = 10W loss

1.0V drop @ 20A = 20W loss

Base Station Grounding Issue

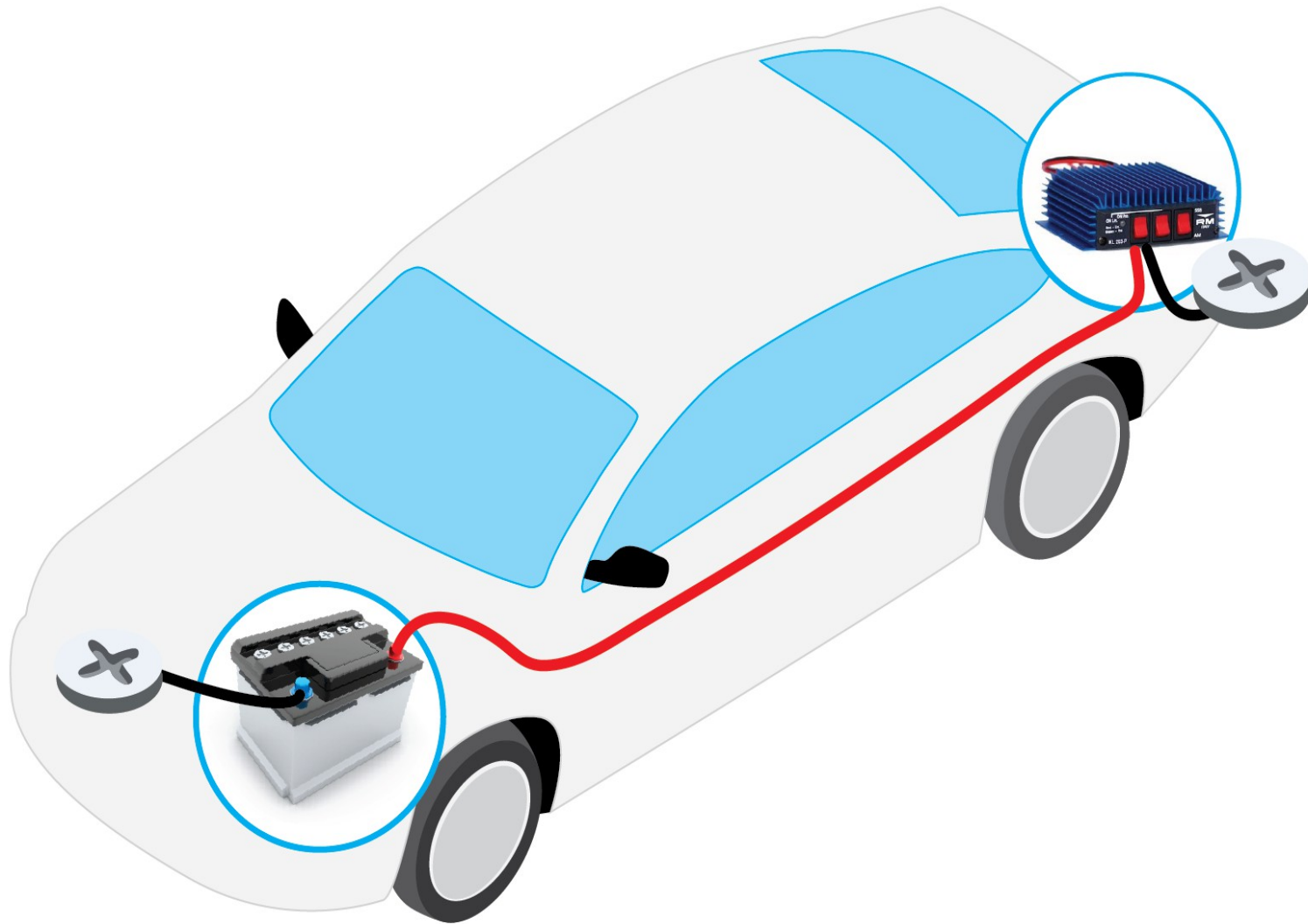


Base Station Grounding Issue

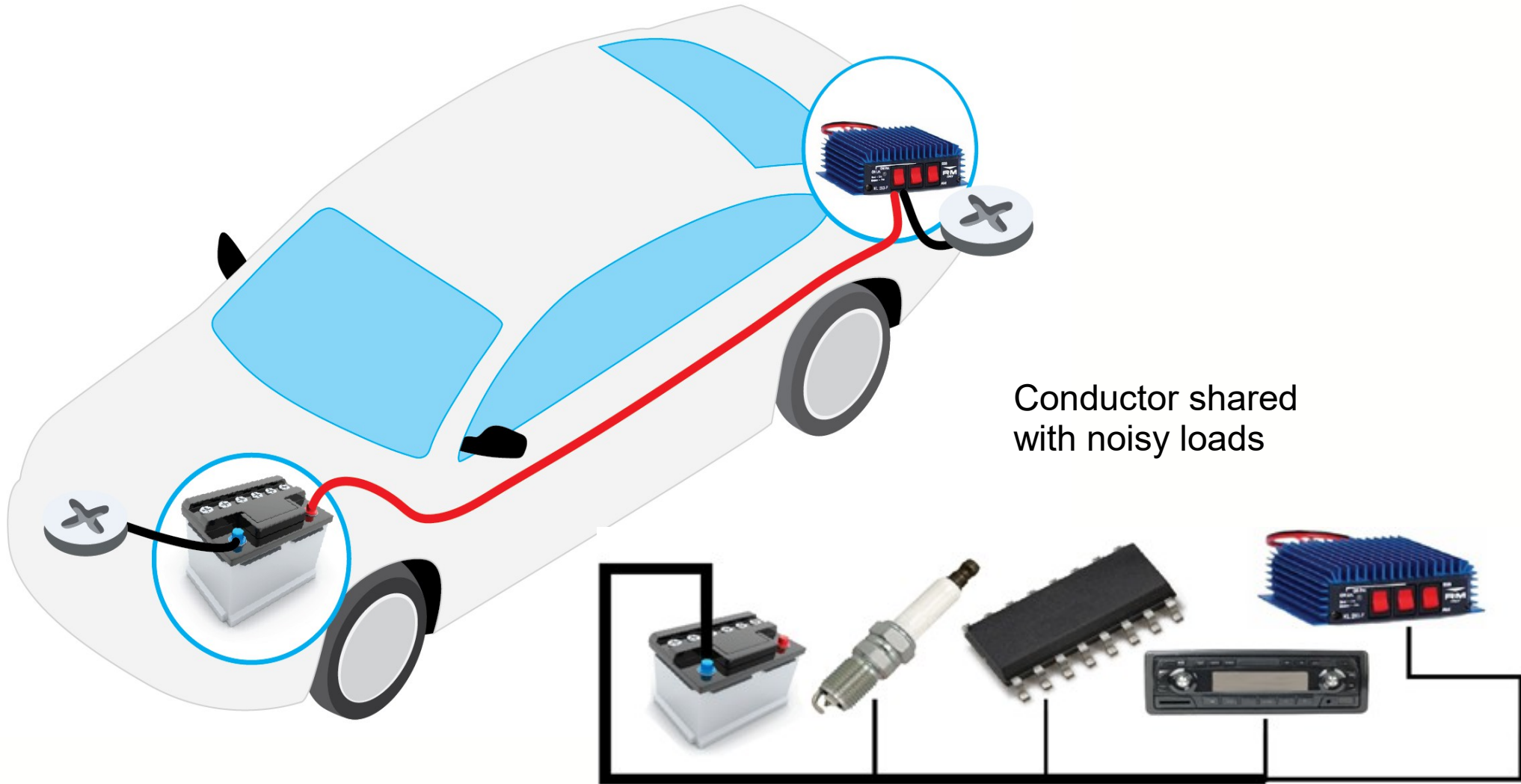


Two ground paths from radio to power supply

Vehicle Grounding Issue



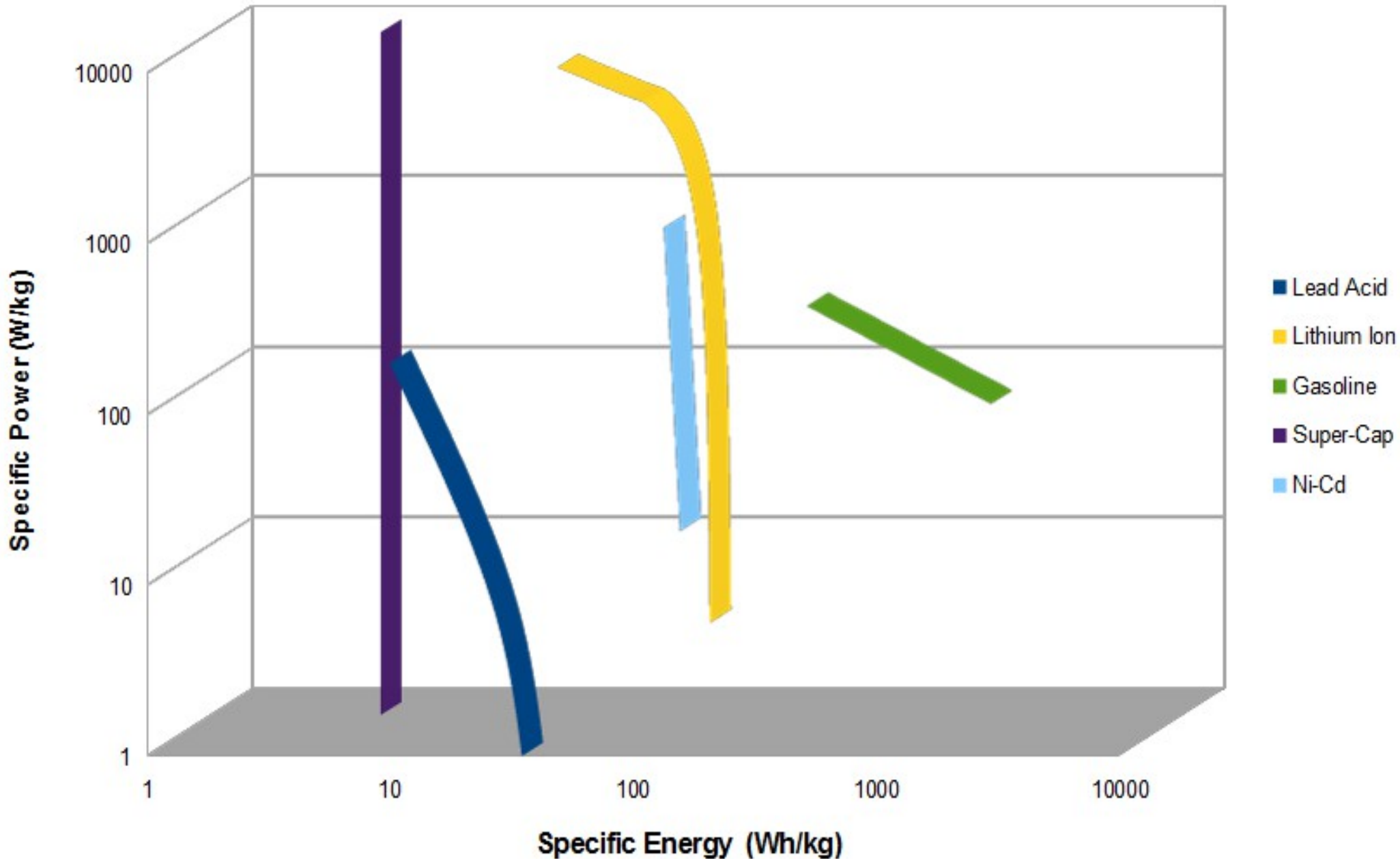
Vehicle Grounding Issue



Conductor shared
with noisy loads

Batteries

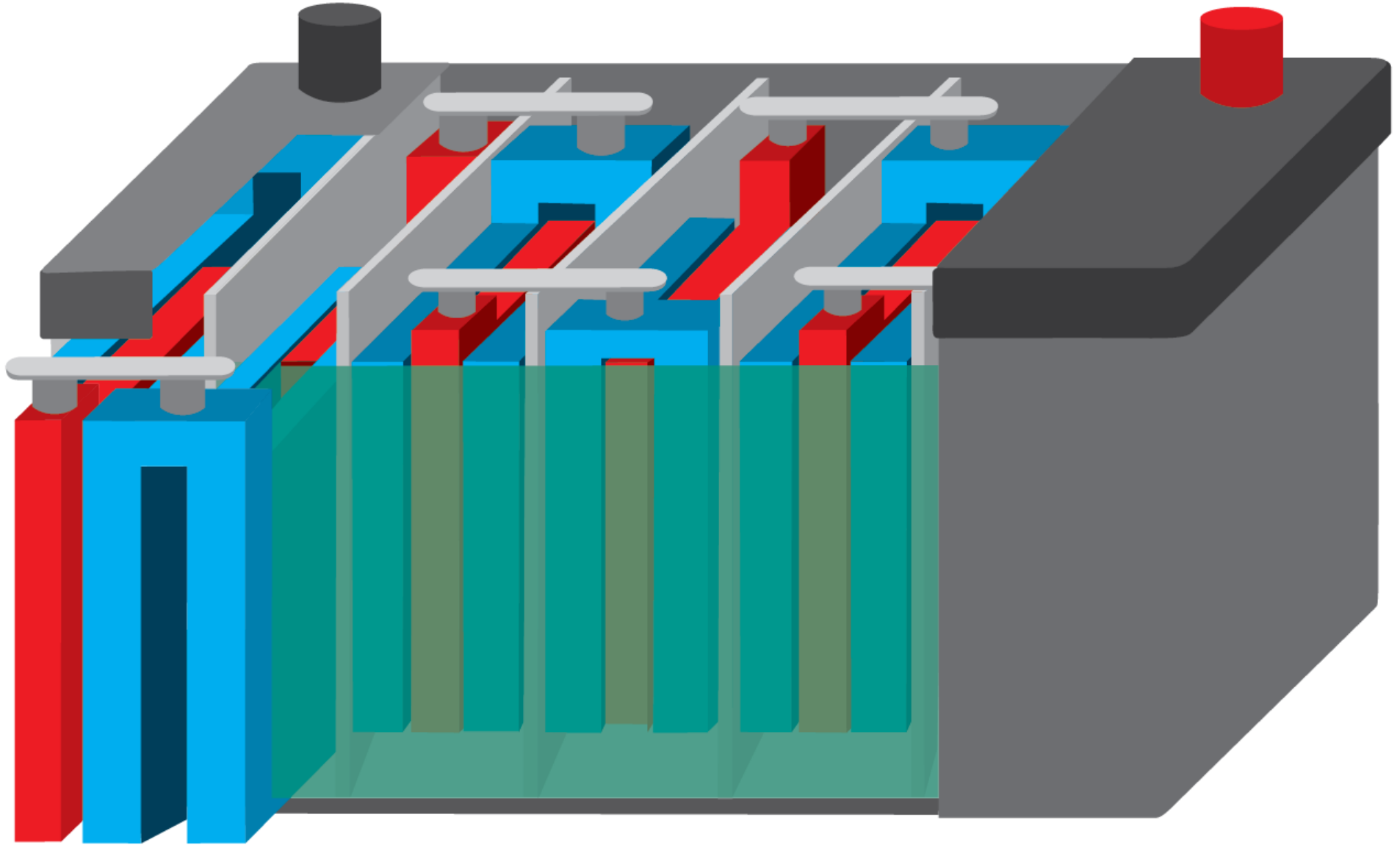
Ragone Chart



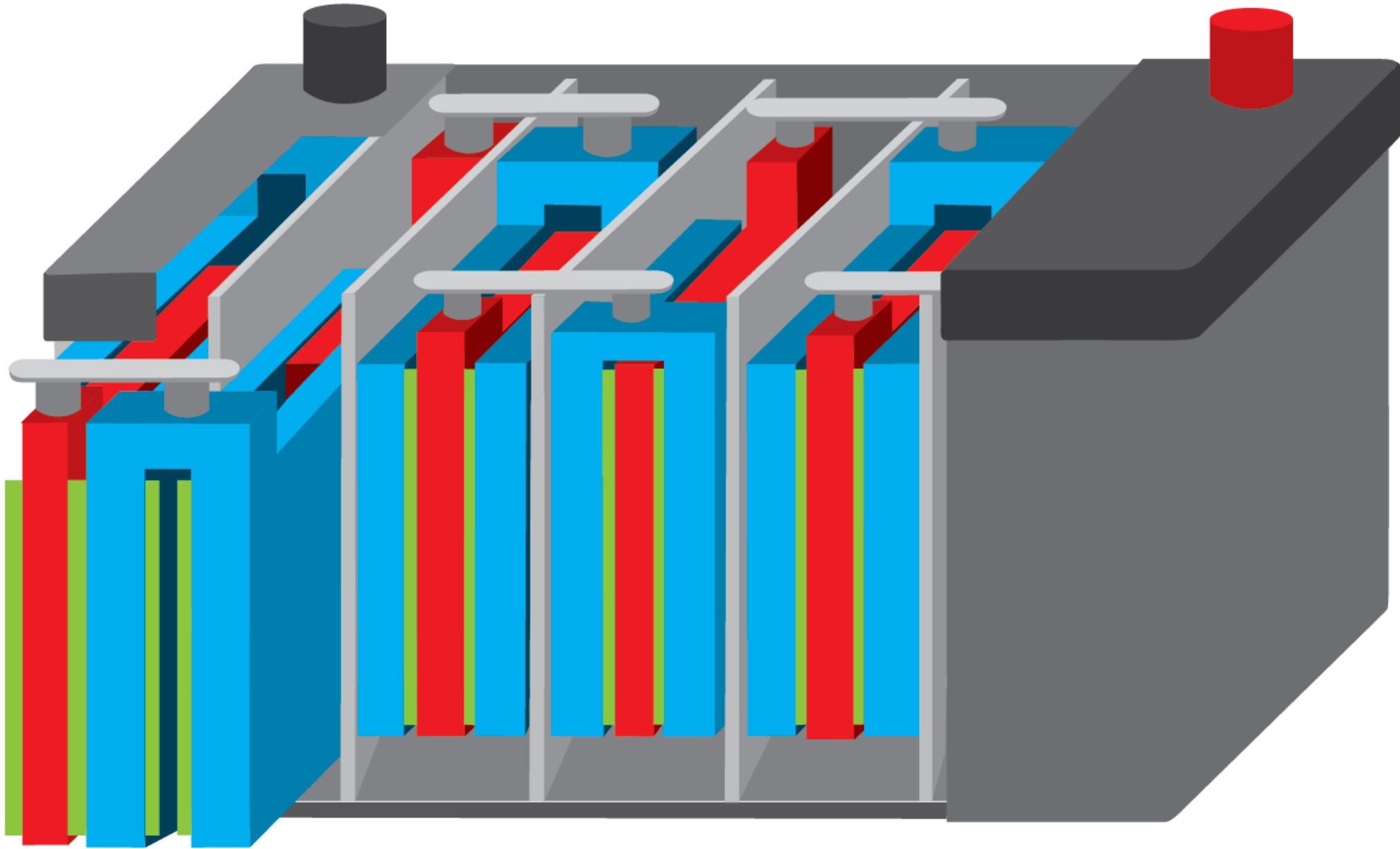
- ALWAYS fuse
- Use Sealed – Not wet
- Do not keep in an airtight enclosure

- Indoor use OK for a modest number of batteries
- Check for local battery disposal places –
Batteries Plus is nationwide and most have a free disposal service

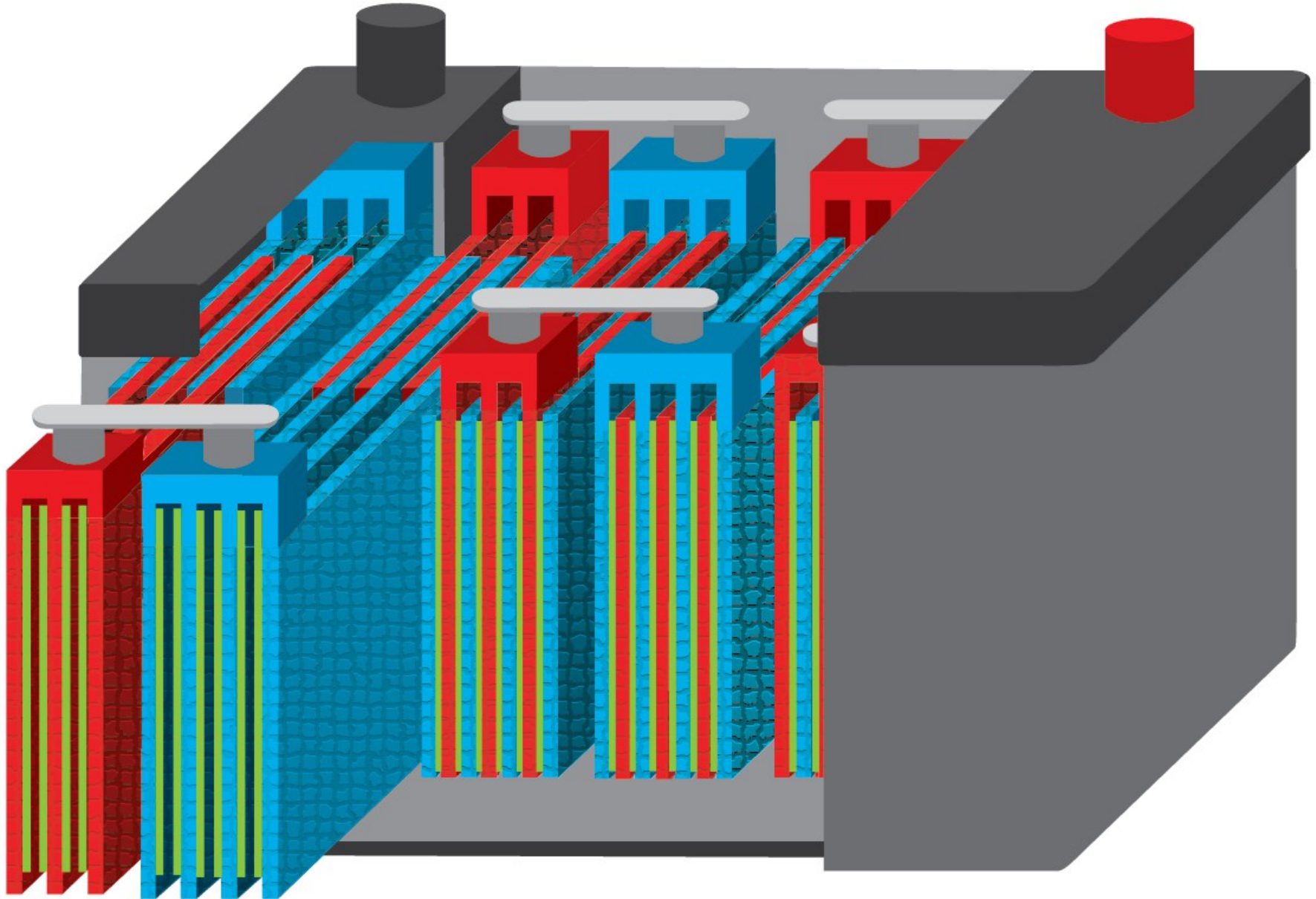
Flooded Lead-Acid



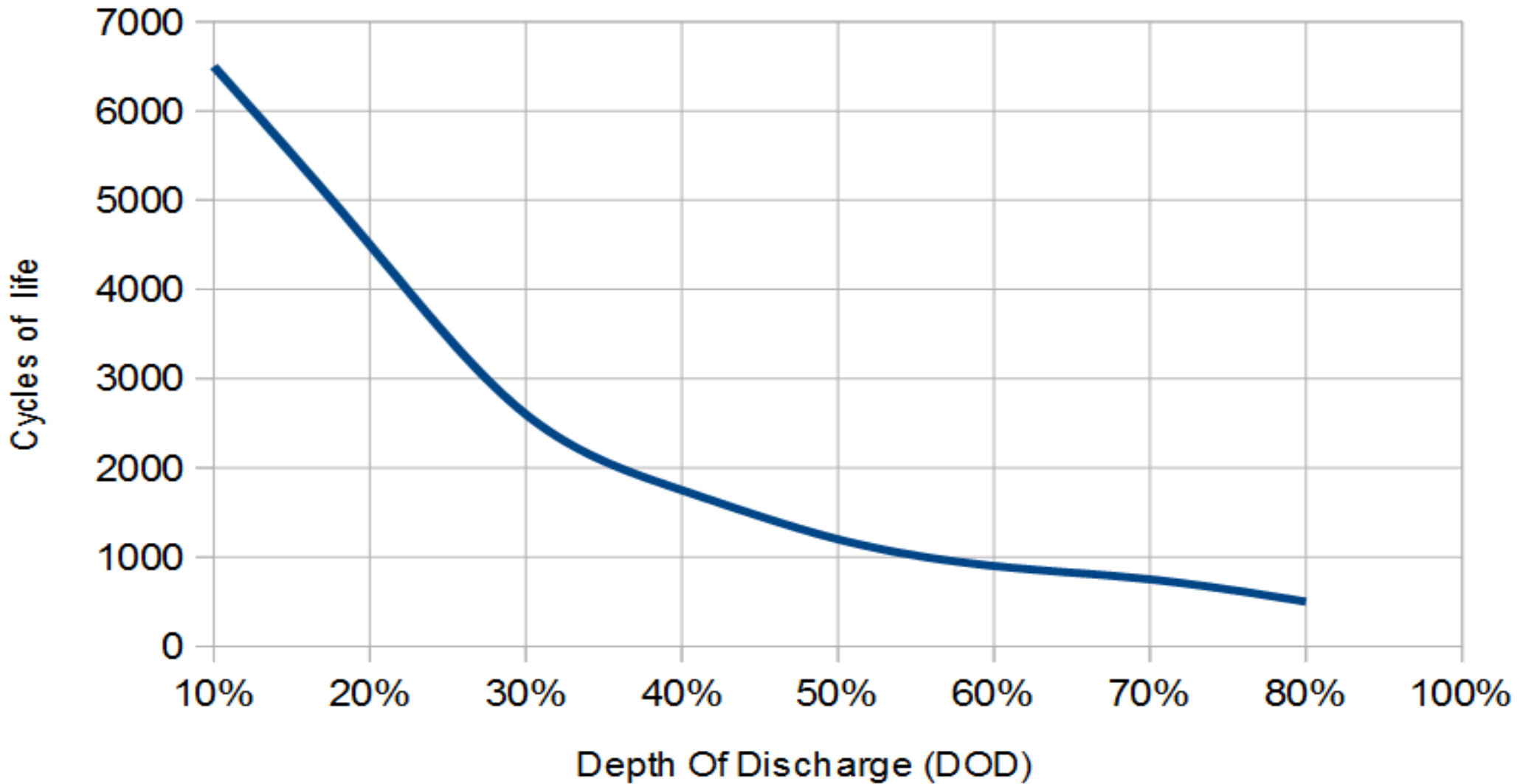
Lead-Acid Gel Battery



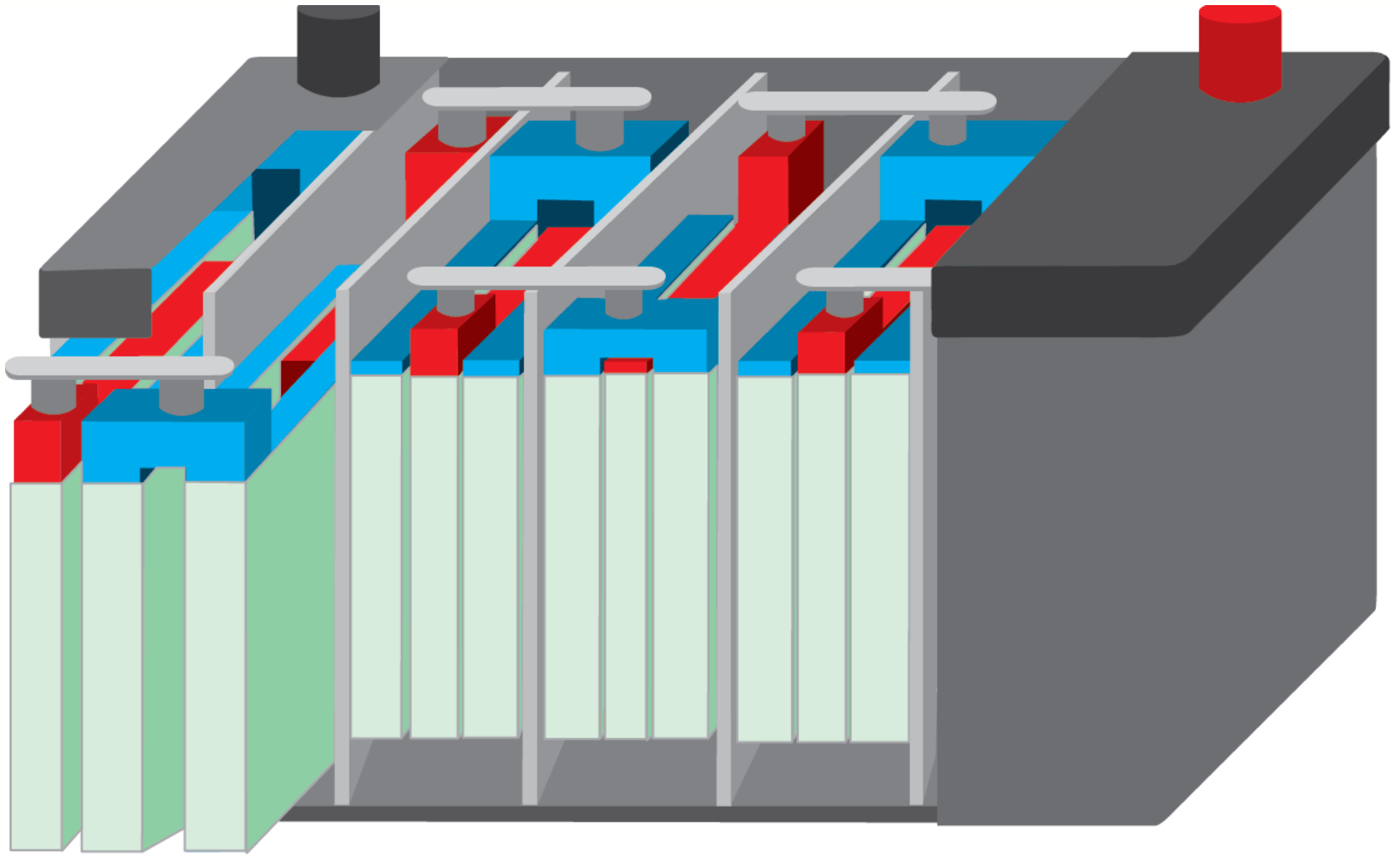
Starter Battery



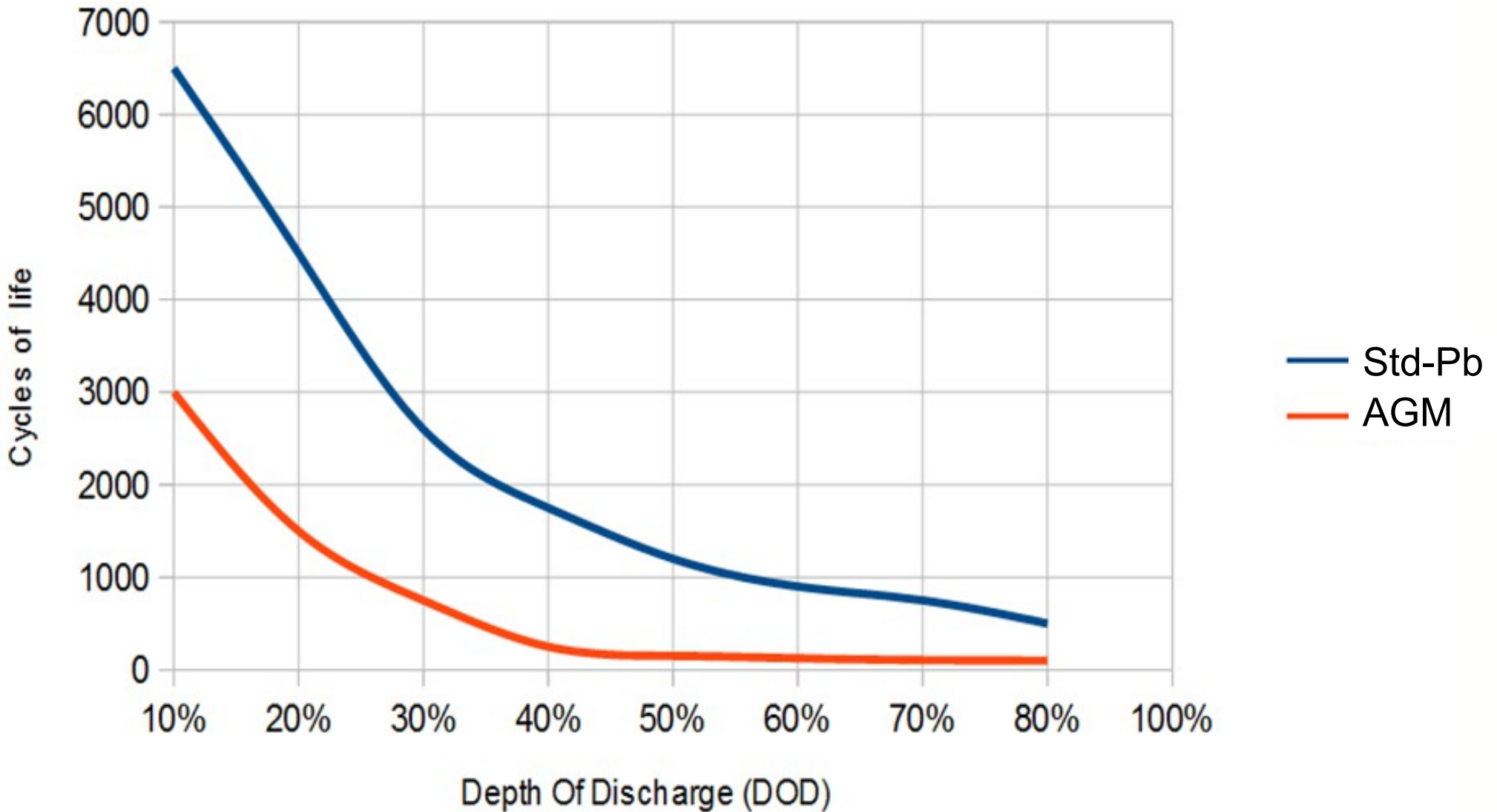
Standard (non-AGM) Lead-Acid



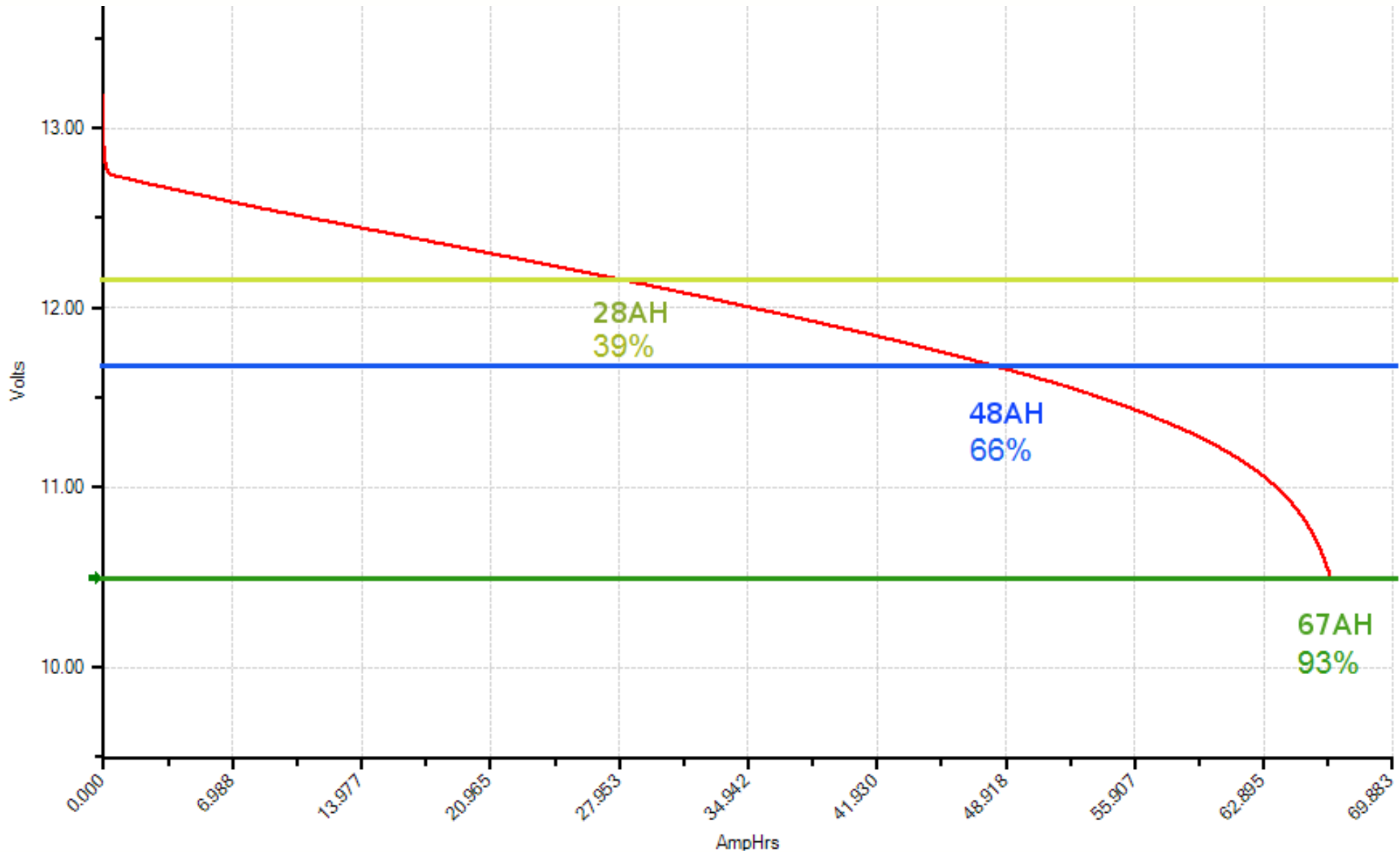
Absorbent Glass Mat (AGM)



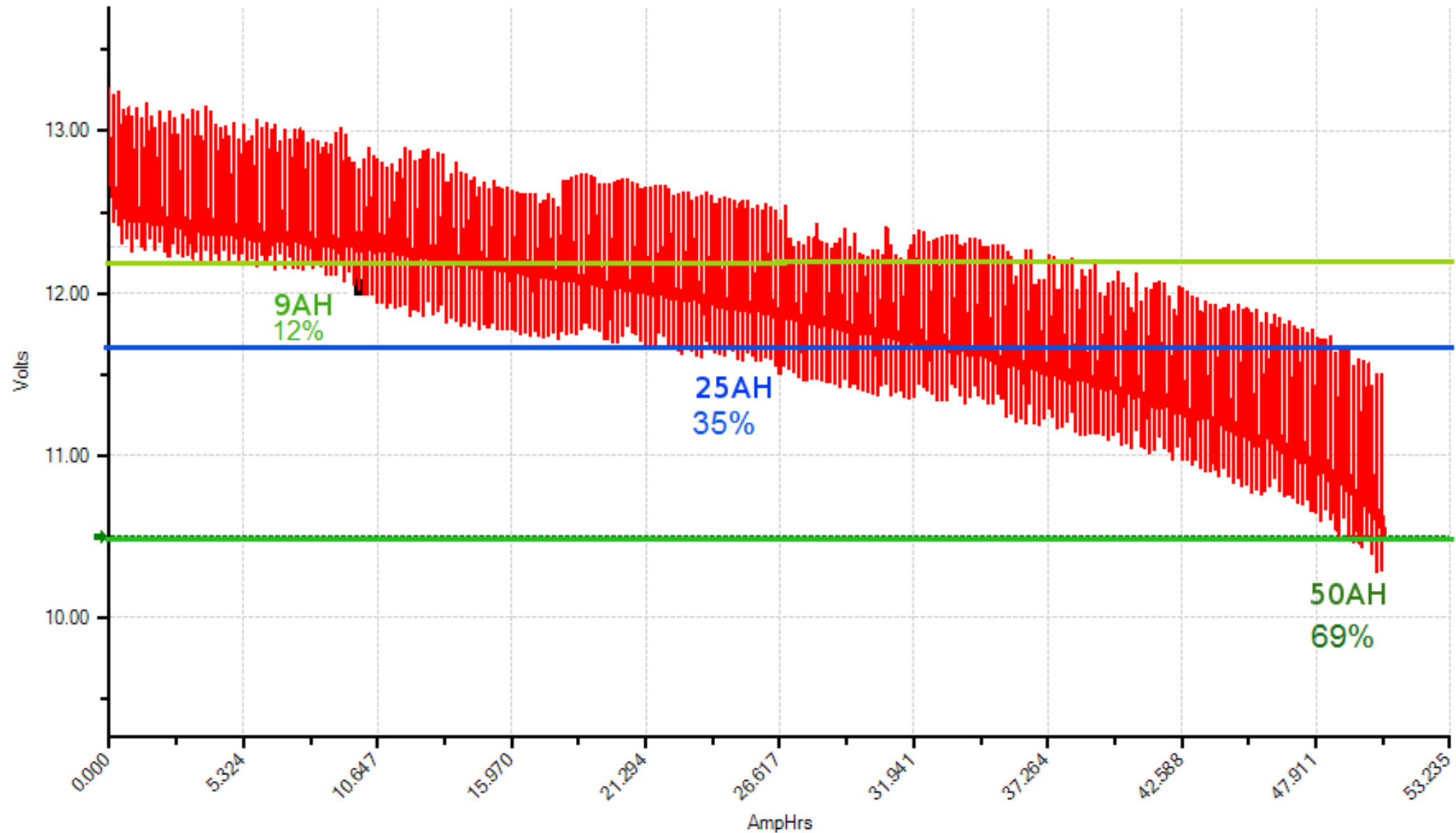
AGM DOD



Lead-Acid Discharge Curve



Transmit Discharge Curve



Alternate: 100W transmit for 30 seconds -- Receive 30 seconds

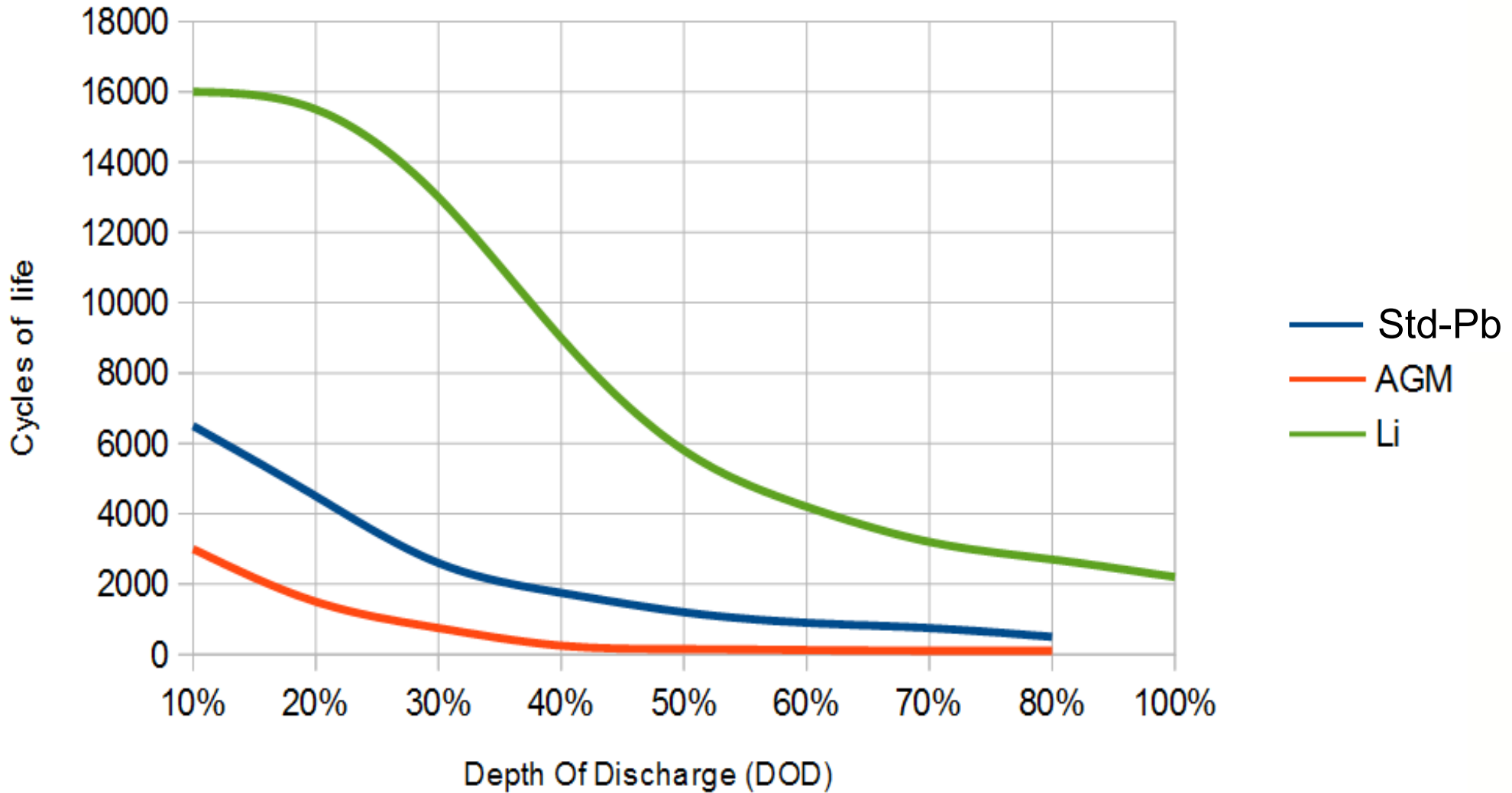


Li-ion Chemistries

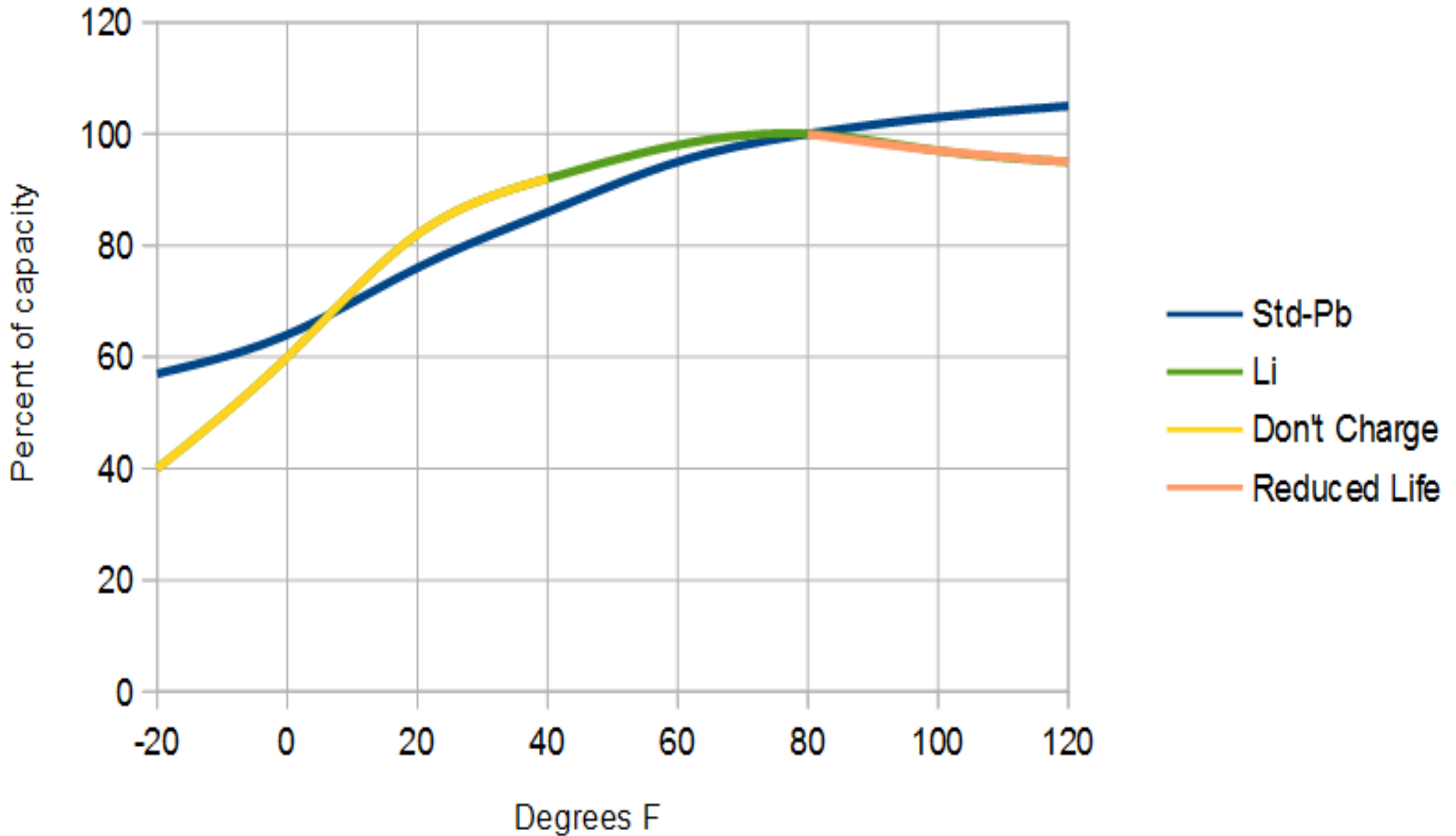


LiFePO_4	\$	High Load	High Life		Safer	Lead-Acid Replacement
$\text{Li}_4\text{Ti}_5\text{O}_{12}$	\$\$\$	High Load	High Life	Heavy	Safer	Electric Cars (Japan)
LiMn_2O_4	\$	High Load	Low Life			Tools
LiNiMnCoO_2	\$			Light		Bikes
LiNiCoAlO_2	\$\$			Light		Electric Cars (US)
LiCoO_2	\$		Low Life	Light		Phones

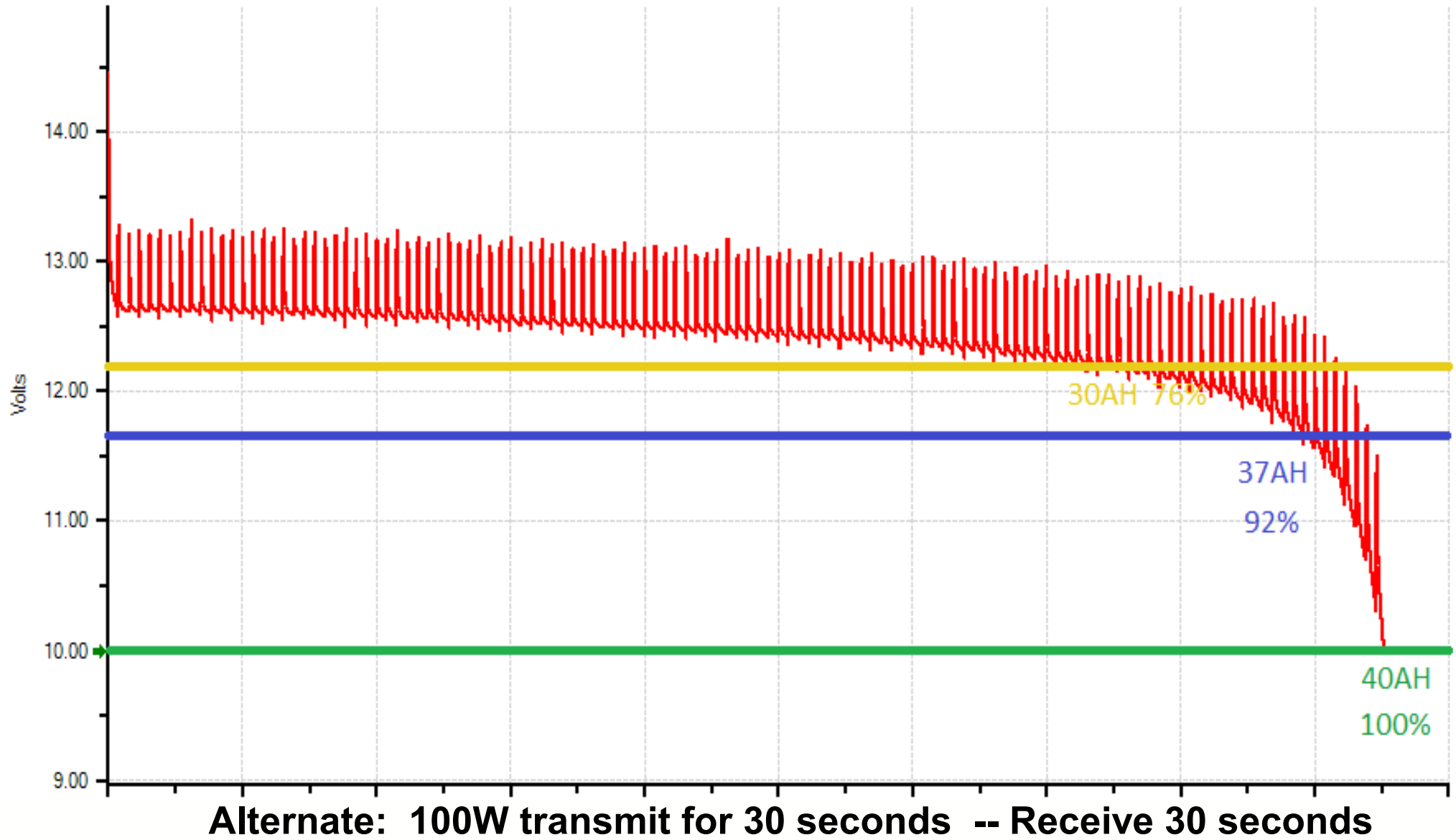
Lithium Battery DOD



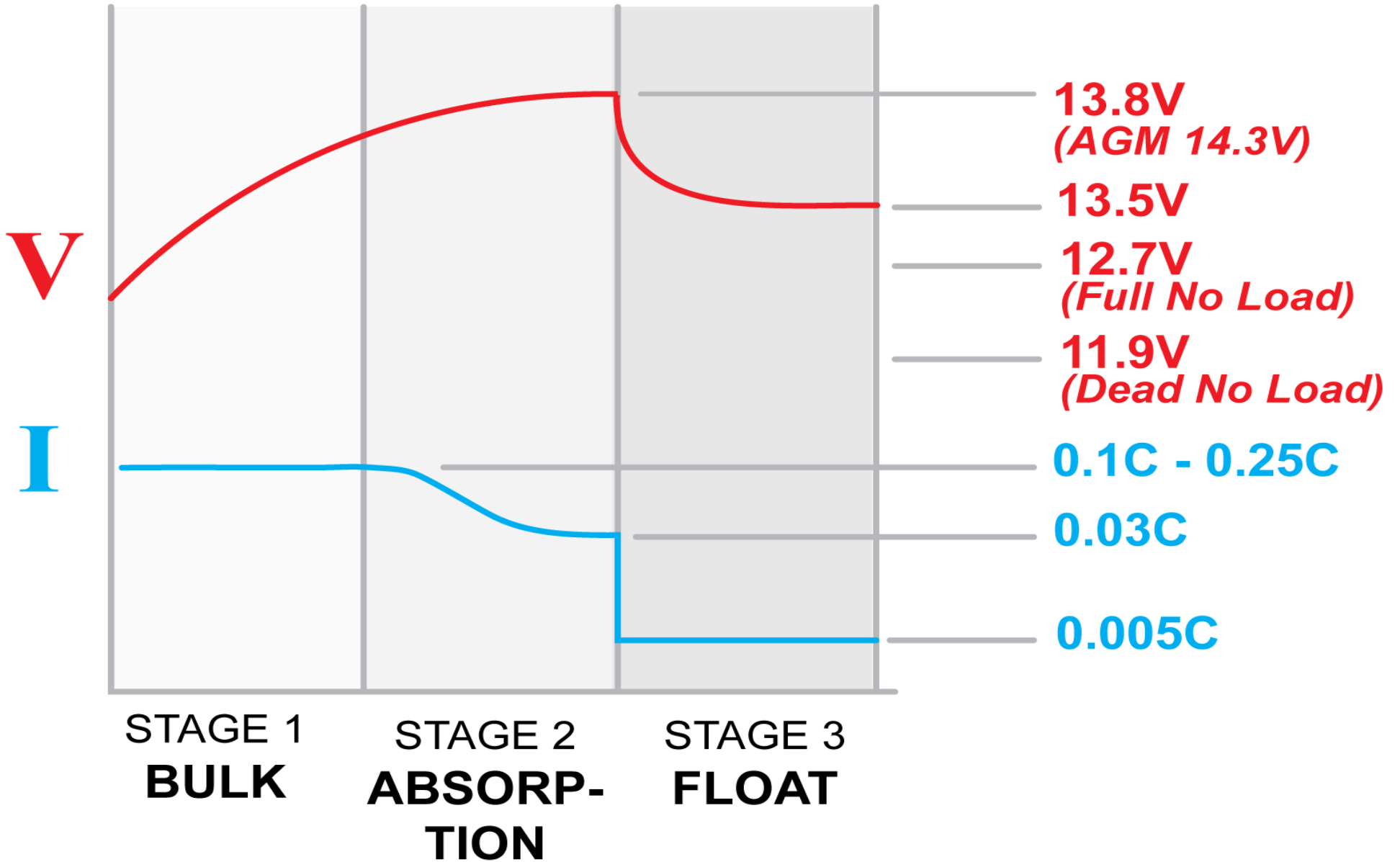
Effects of Temperature



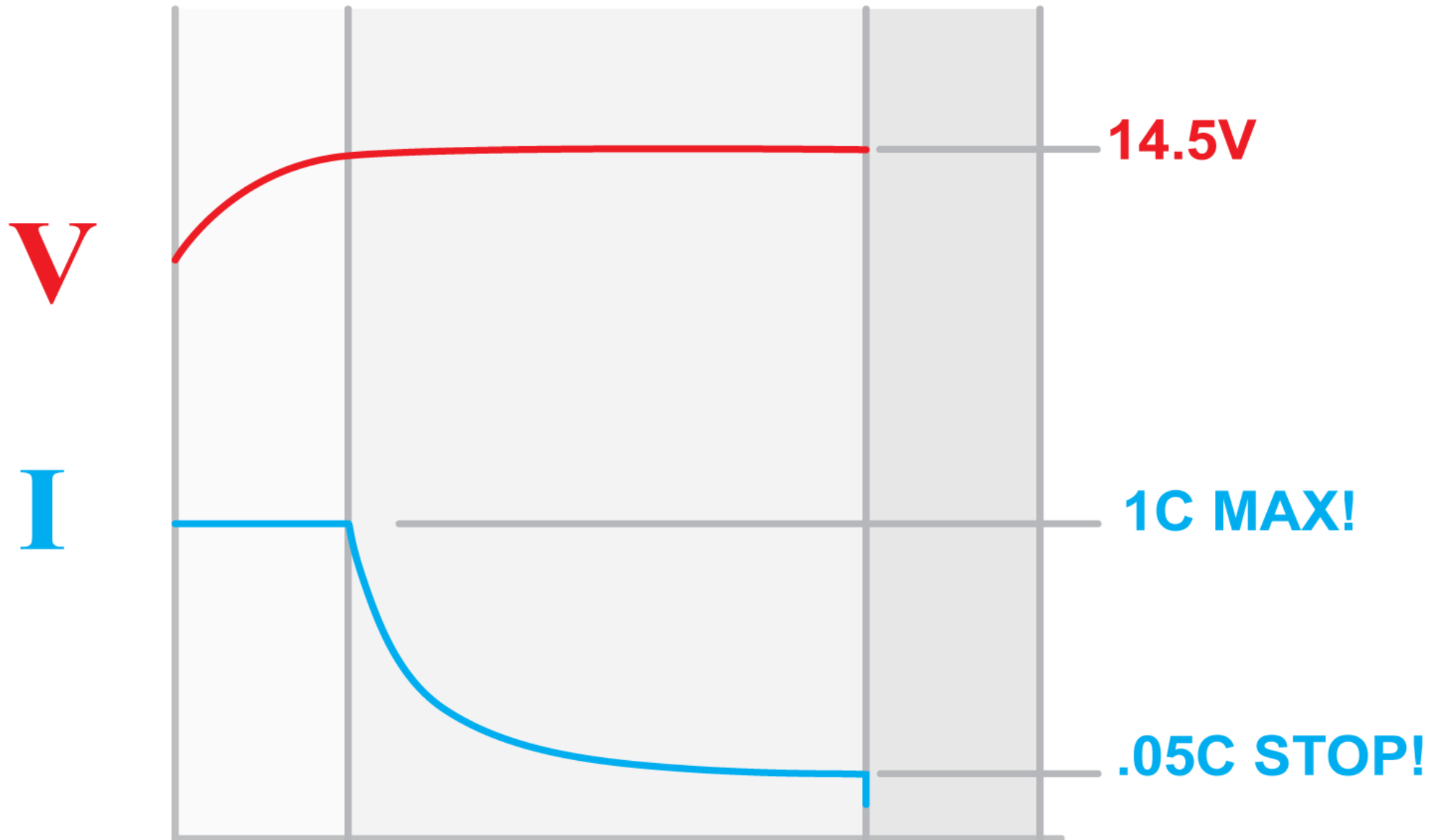
Li Discharge Curve



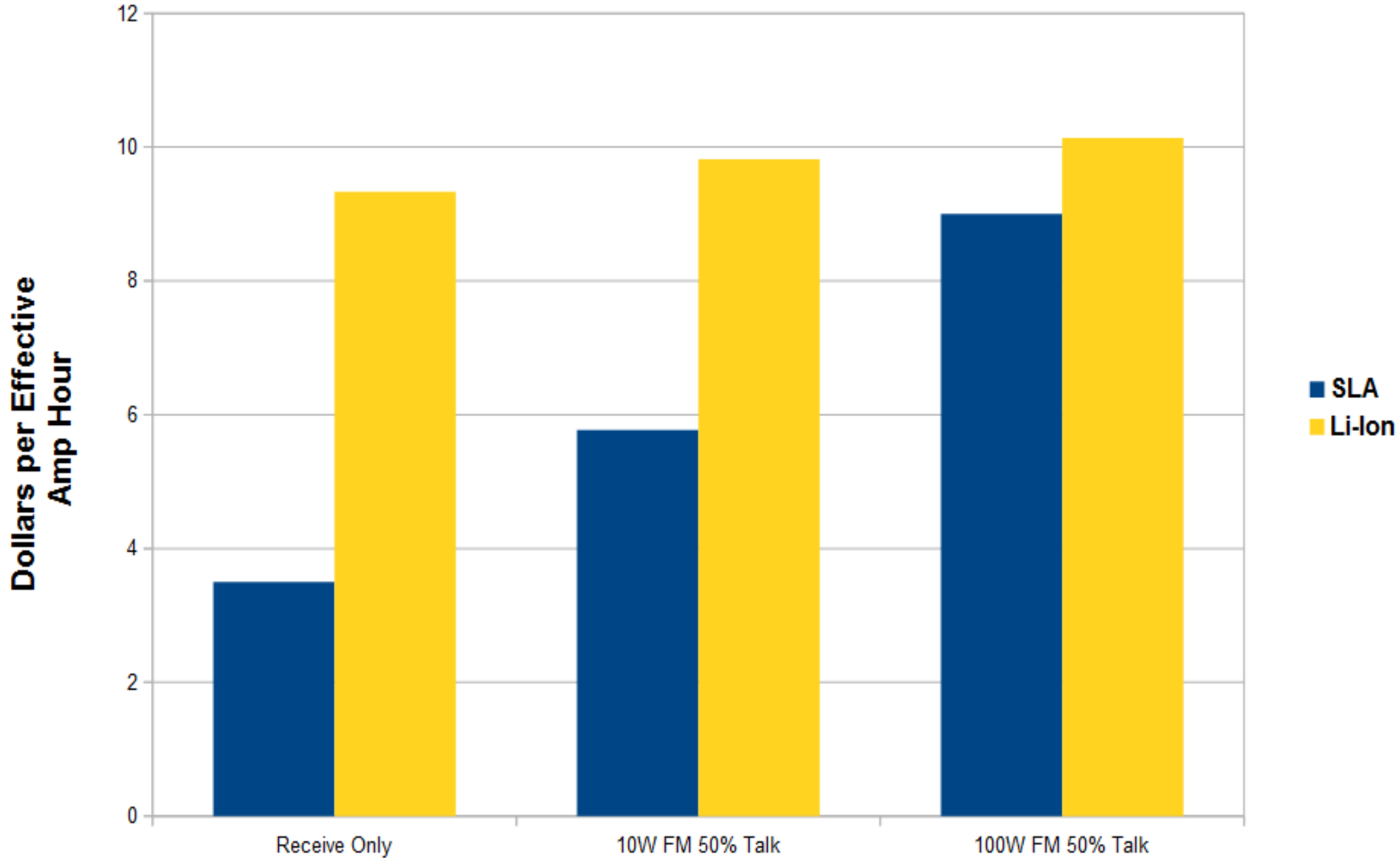
Lead-Acid Charging



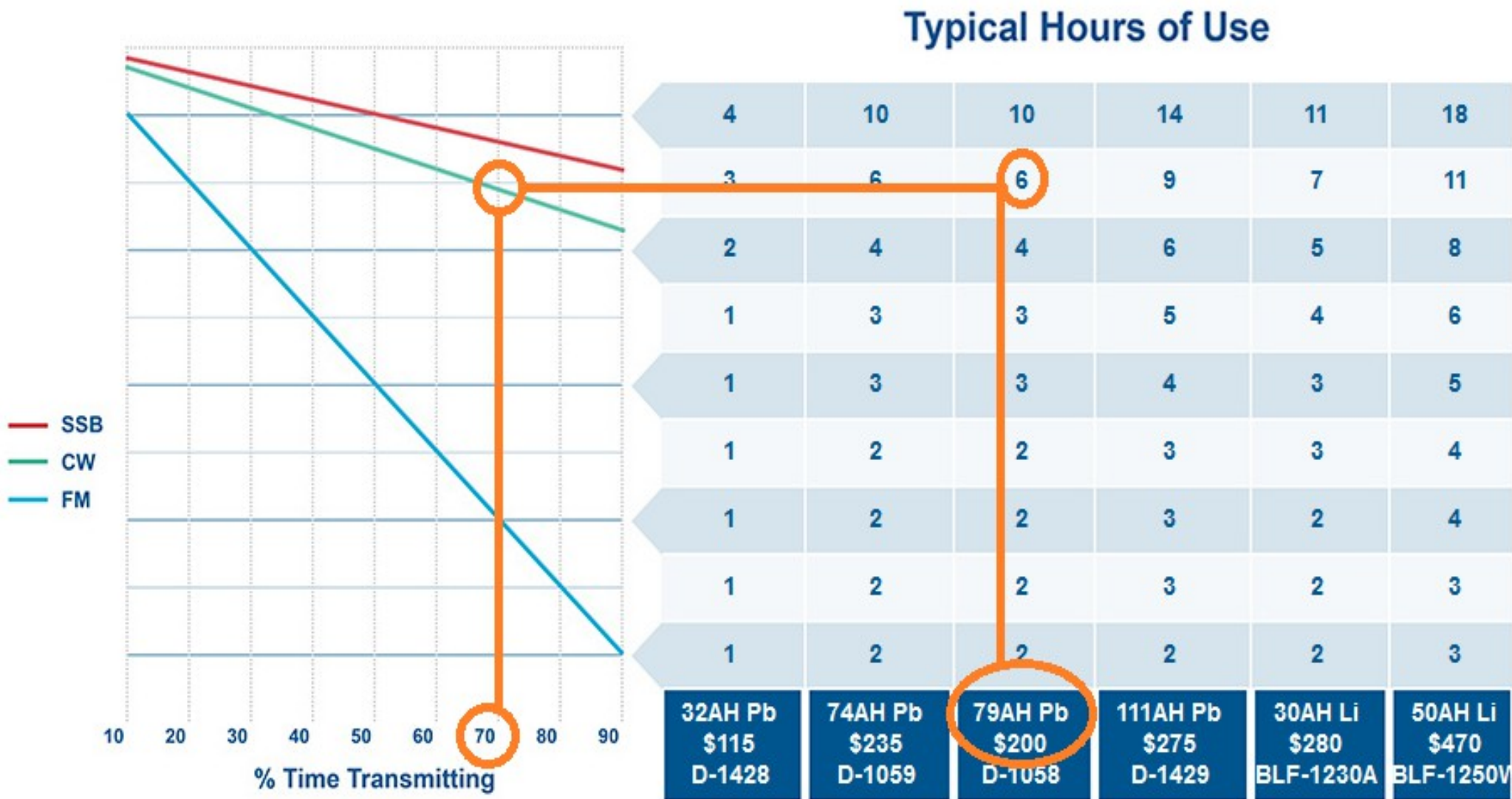
LiFePO4 Charging



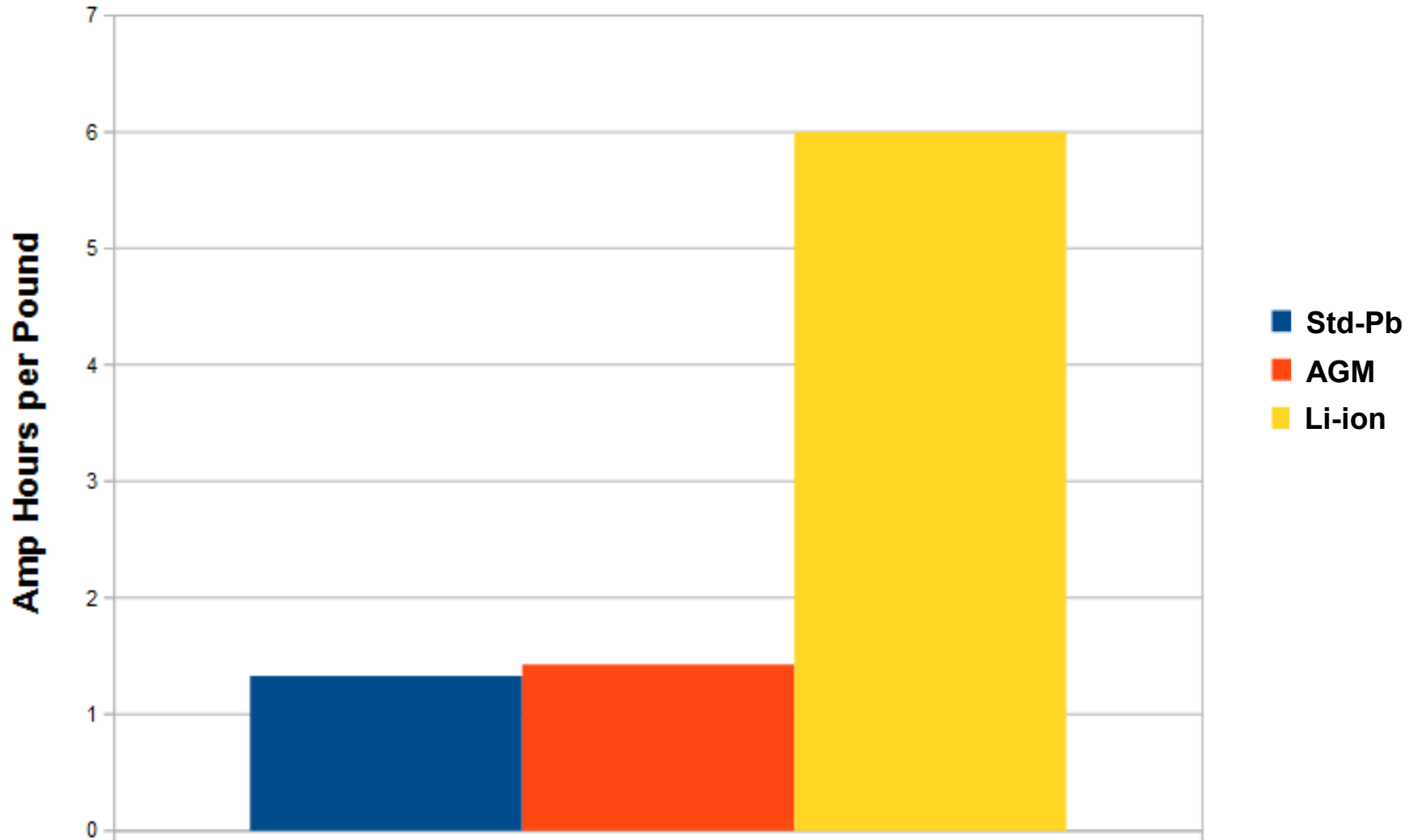
Battery Cost Comparison



www.westmountainradio.com > Support > Calculators > Battery Capacity Calculator

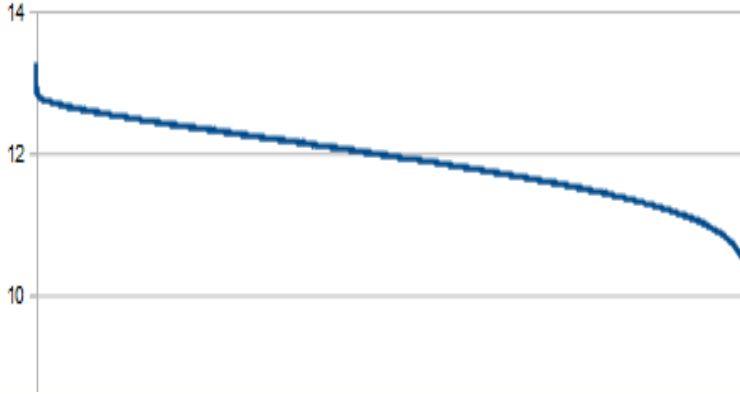


Battery Weight



Battery Boosting

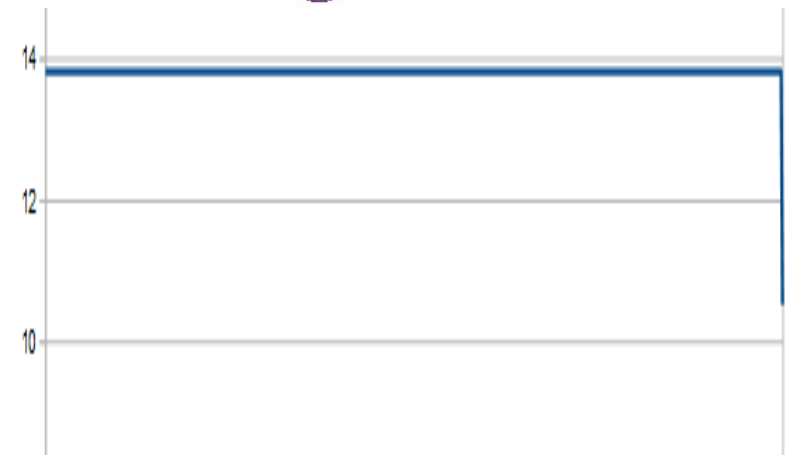
Battery Booster



Battery



Radio



Booster Performance

	Apx Cost	100W SSB Transmit Time
74 AH Lead Acid	\$300	10 Hours
40 AH LiFePO4	\$360	10 Hours
74 AH Lead Acid With booster	\$300 +\$250 NRE	15 Hours
60 AH LiFePO4	\$570	15 Hours

2004 QST Article on Battery Boosters
Dan Kemppainen N8XJK

Design

TG Electronics
Tim Gedeon

Manufacturing

West Mountain Radio
N8XJK Super Booster

Re-Design
Manufacturing

40A Continuous
Extremely low RFI

Can combine for 80A or 120A

Battery Testing

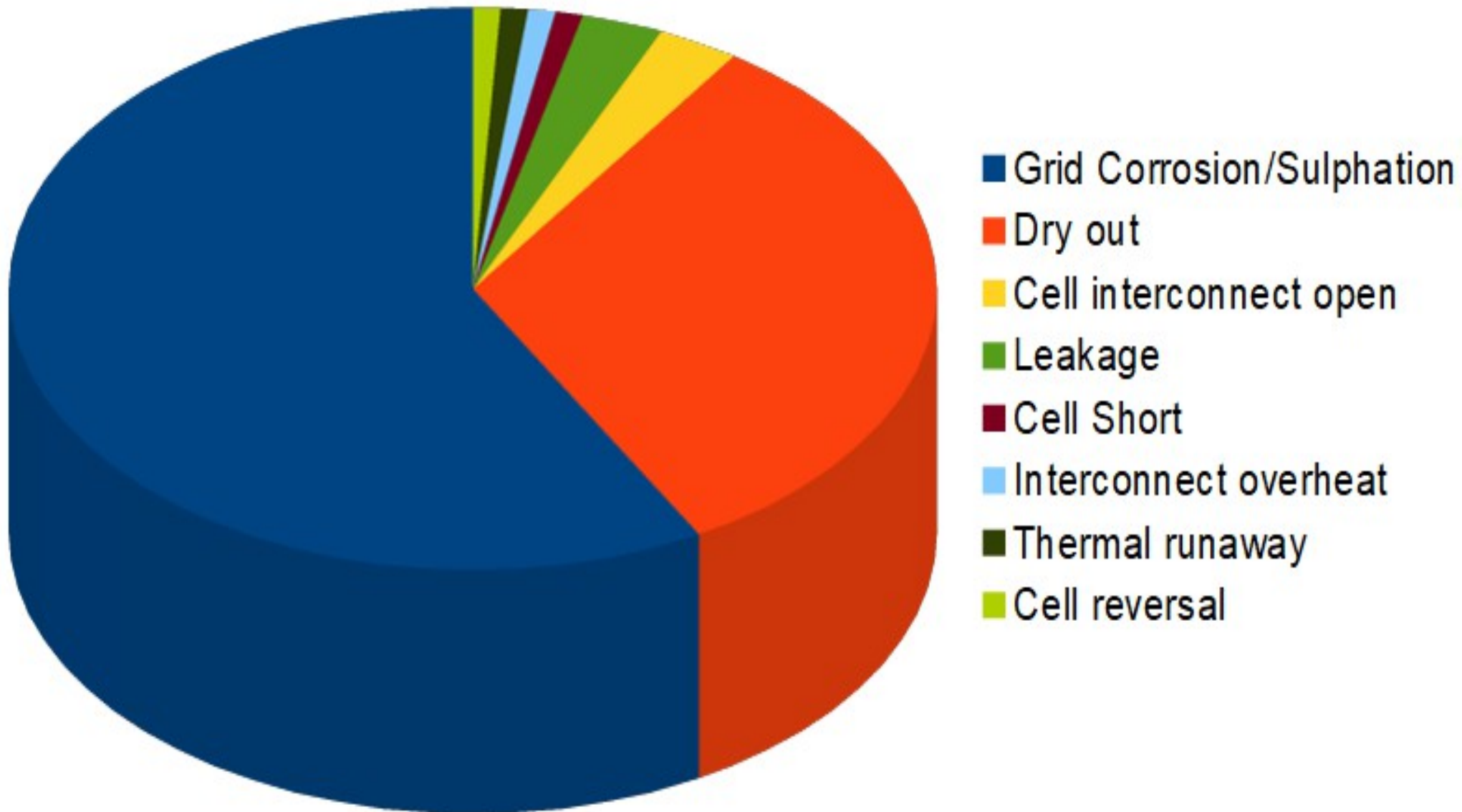
Batteries are expensive & there is a substantial variation in life

- Lead acid batteries life spans typically range from 2 to 10 years
- 64% of Lead Acid batteries die by age 7
- Expect 5 good years at 77F and 3 years at 90F

Predicting End of Life

- When there is a 20% drop in capacity you have exhausted 85% of the battery life

Lead Acid Battery Failures



Grid Corrosion/Sulfation

- Plates change chemistry when a battery discharged
- Plates restored when charged
- Leaving batteries discharged inhibits full restoration
- High temperature while discharged accelerates hardening

Dry out

- When batteries are charged or discharged too fast they vent gas.
- With a sealed battery that vaporized electrolyte is permanently lost

Measure voltage under load

- Fast
- Similar results to measuring impedance
- Interpretation requires knowledge of the specific battery
- In 60% of Pb batteries voltage under load drops to under 10.5V in the last 15% of life.

Measure true capacity

- Takes up to 20 hours for a Lead Acid battery.
- In 95% of Pb batteries capacity drops from 80% to 20% in last 15% of life (maybe a year).

Test Methods

	Voltage under load		True Capacity	
	Detects	Predicts	Detects	Predicts
Grid Corrosion/ Sulfation (Most common failure)	100%	95%	100%	95%
Dry out (A third of all fails)	15%	0%	100%	95%
All Failures =>	75%	57%	100%	95%



- Discharge: Regulated Constant Current
- Power Profile: Characterize Peak Power Point of Power Supplies, Solar Panels, & Batteries
- (Record Voltage ; Increment Current)
- Charge Monitor: Recording Voltmeter Charts Voltage vs. Time
- Mission Profile: Pass / Fail Evaluation of Set Current Draw for Specified Number of Minutes

New Test - CBA #43532

Profile: <Auto-Check> Delete

Battery

Battery Type: Lead Acid

Voltage: 13.2 Cells: 6 Detect

Capacity (Ah): 74.000 Weight: 95.000 kg

Test

Test Name: New Test

Cutoff V: 10.50

Sample Rate: 1s

Test Type: Discharge

Test Amps: 4.00 Suggest

Graph: AmpHrs

Graph Temperature

Recovery time: 60 sec

Capacity Check Pass/Fail

Capacity Type: Percent

Pass Threshold: 80.0 Suggest

Amplifier

No Amplifier

One Amplifier

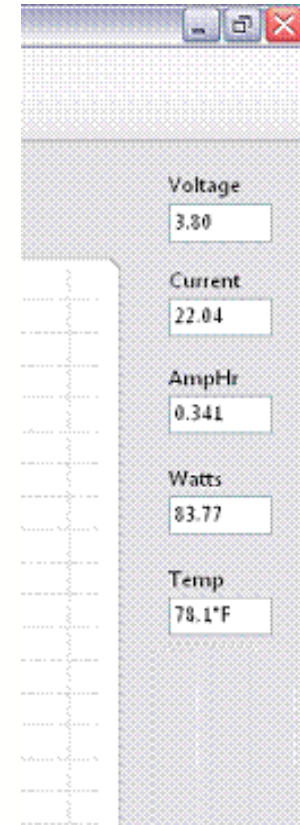
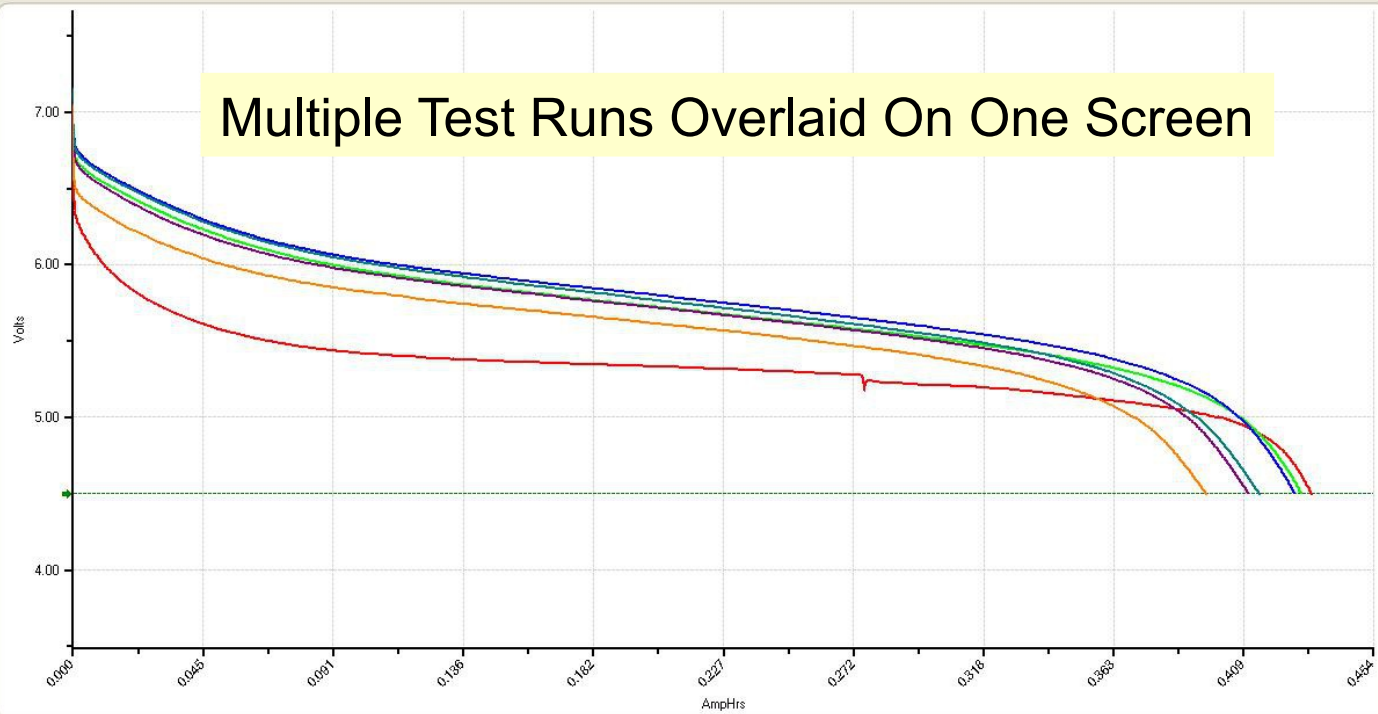
Two Amplifiers

2000W (20X)

Start OK Cancel

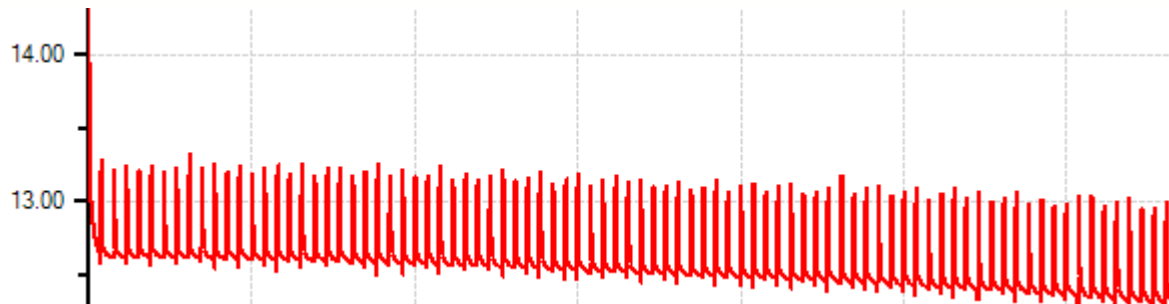
Canon Best 1: 5 NiMH cells, 0.7 Ah @ 1.00A
Canon Best 2: 5 NiMH cells, 0.7 Ah @ 1.00A
Canon Best 3: 5 NiMH cells, 0.7 Ah @ 1.00A
Canon Best 4: 5 NiMH cells, 0.7 Ah @ 1.00A
Canon Best 5: 5 NiMH cells, 0.7 Ah @ 1.00A
Canon Best 6: 5 NiMH cells, 0.7 Ah @ 1.00A

Multiple Test Runs Overlaid On One Screen



Real Time Data Display

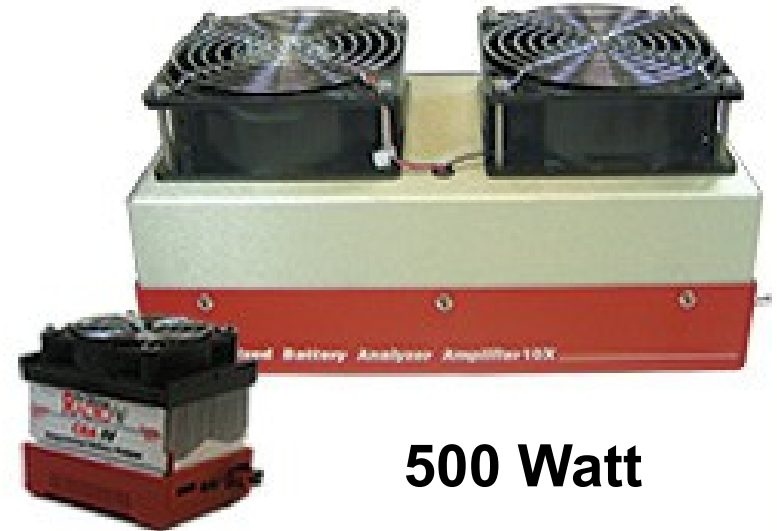
- Duty Cycle: Programmable On / Off Cycles
- Constant Power: Current Increases as Battery Voltage Drops
- Multiple Discharge: Multiple Load / Time Intervals with Looping
- Option to Simulate Actual Usage Patterns
- Constant Resistance: Programmable load,
 - allows Current to Decrease as Battery Voltage Drops
- Ragone Power Density: Energy vs Mass (Watt-hrs / kg)
- Lead Wire Resistance Voltage Calibration



CBA Models



150 Watt



500 Watt



10 Watt

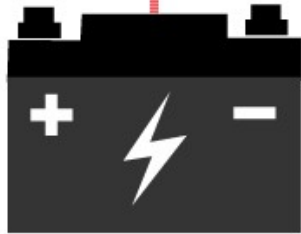


1000 Watt



2000 Watt

Custom Discharge Profiles

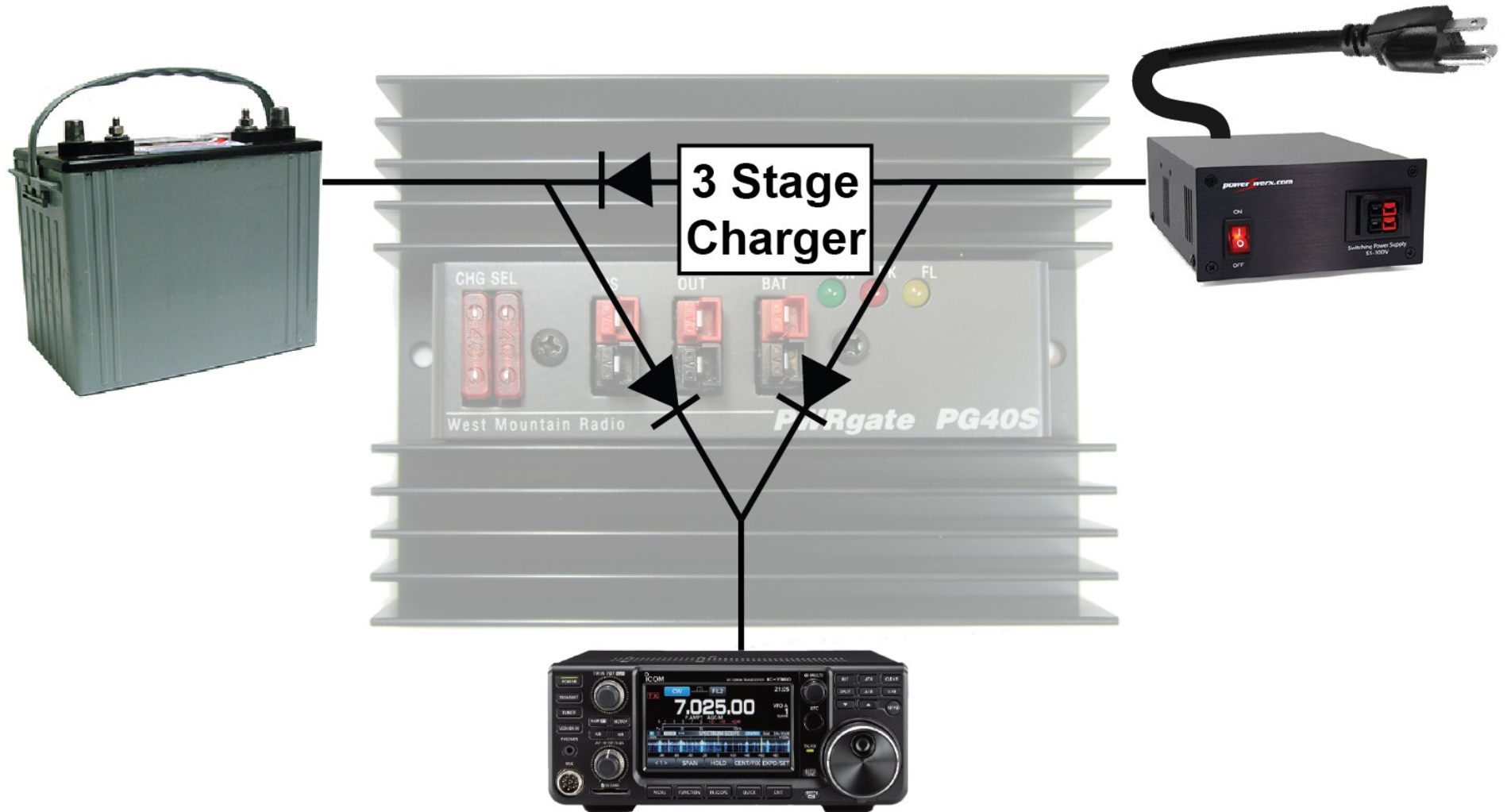


	A	B	C	D
1	#	Time (HH:MM:SS)	Voltage (V)	Current (A)
2		00:00:00	11.65	0.063
3		10:00:01	11.65	0.063
4		20:00:02	11.65	0.063
5		30:00:03	11.65	0.063
6		40:00:04	11.65	0.063
7		50:00:05	11.65	0.063
8		60:00:06	11.65	0.063
9		70:00:07	11.65	0.063
10		80:00:08	11.65	0.063
11		90:00:09	11.65	0.063
12		100:00:10	11.65	0.063
13		110:00:11	11.65	0.063
14		120:00:12	11.65	0.063
15		130:00:13	11.65	0.063
16		140:00:14	11.65	0.063
17		150:00:15	11.65	0.063
18		160:00:16	11.65	0.063
19		170:00:17	11.65	0.063
20		180:00:18	11.65	0.063
21		190:00:19	11.65	0.063

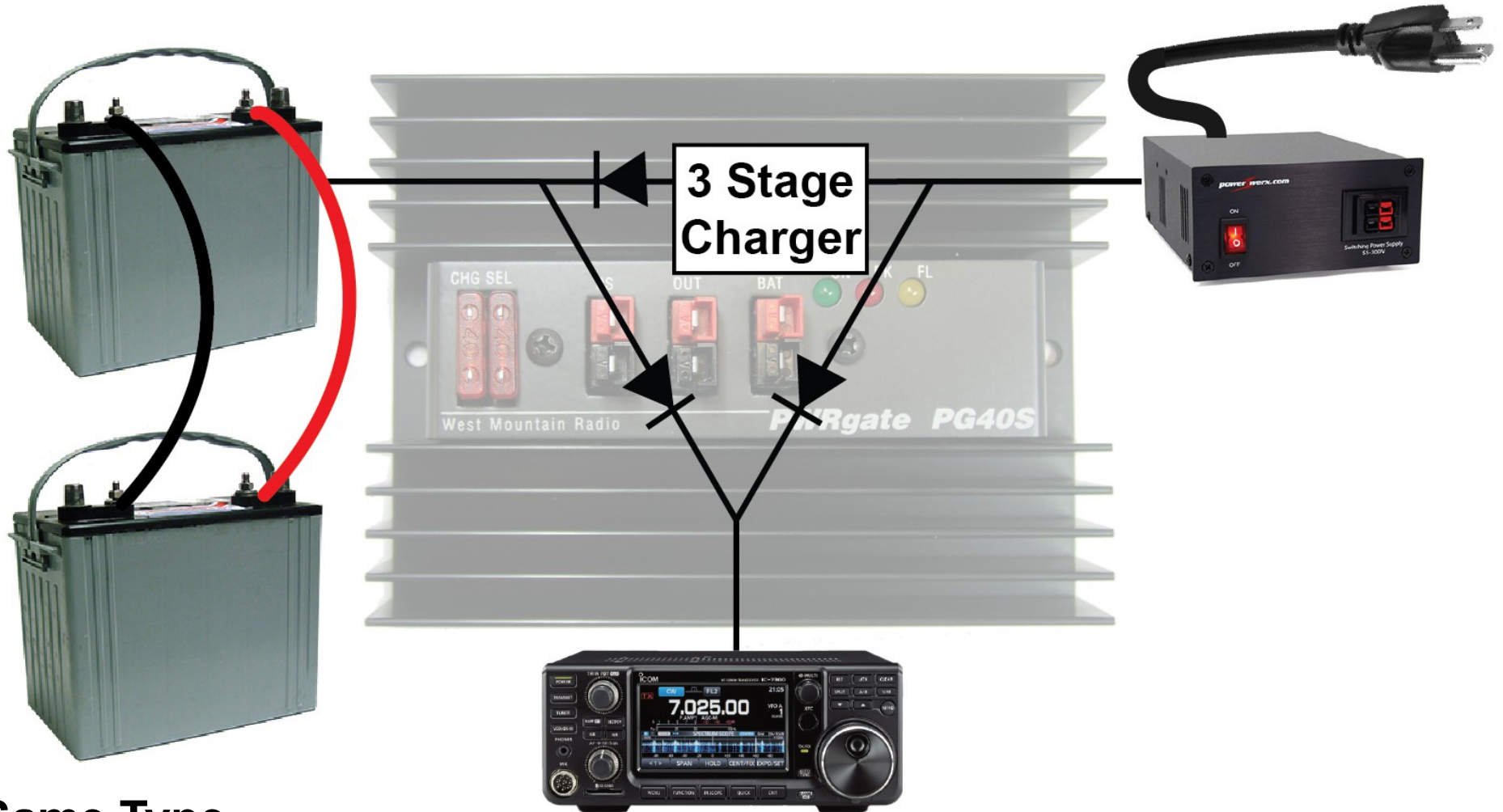


UPS

UPS Configuration



Batteries in Parallel



- Same Type
- Same Age
- Test periodically

Solar Power

Example Solar Panels



30W 36" x 12"

100W 43" x 36"

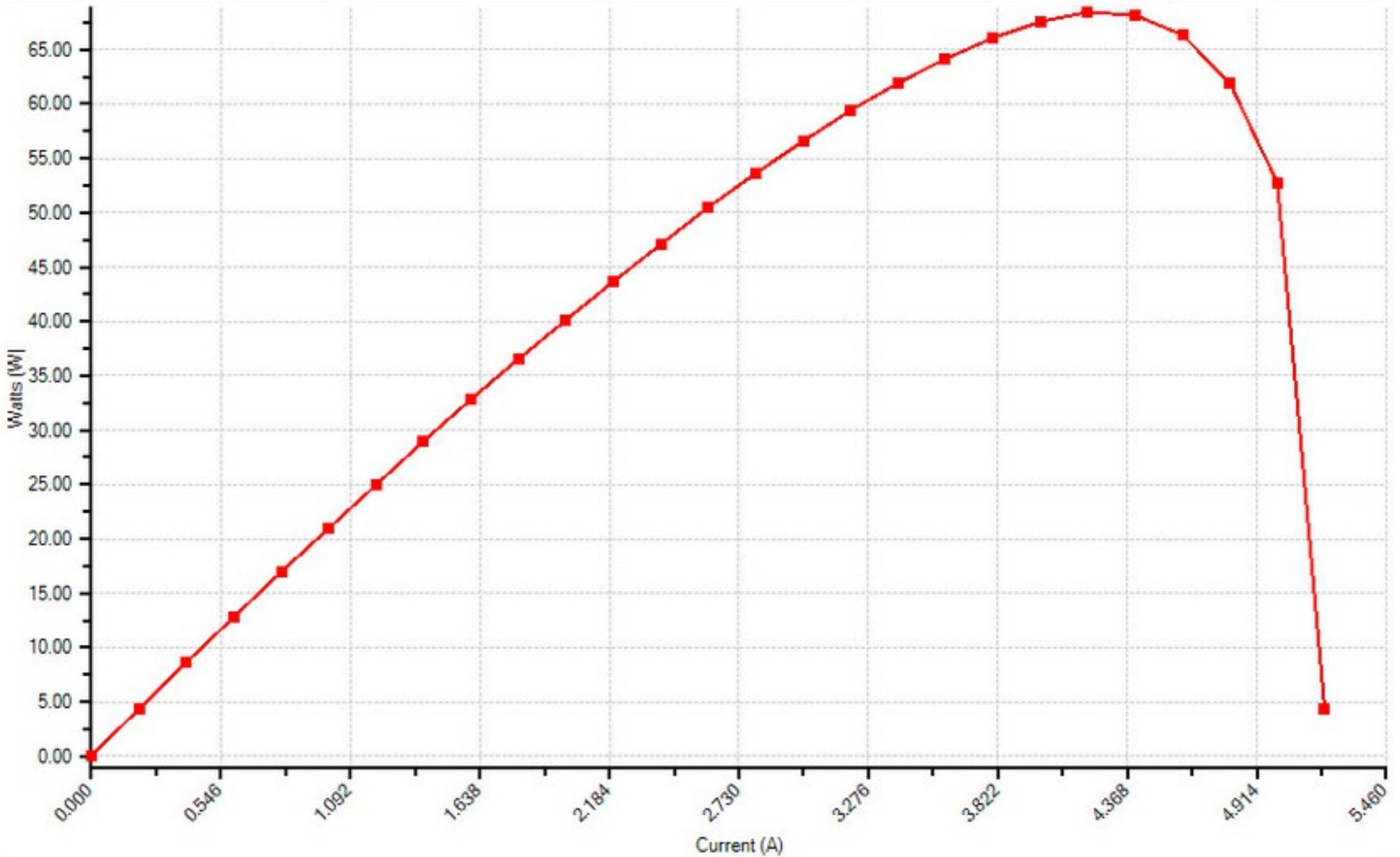
200W 56" x 39"

300W 66" x 38"

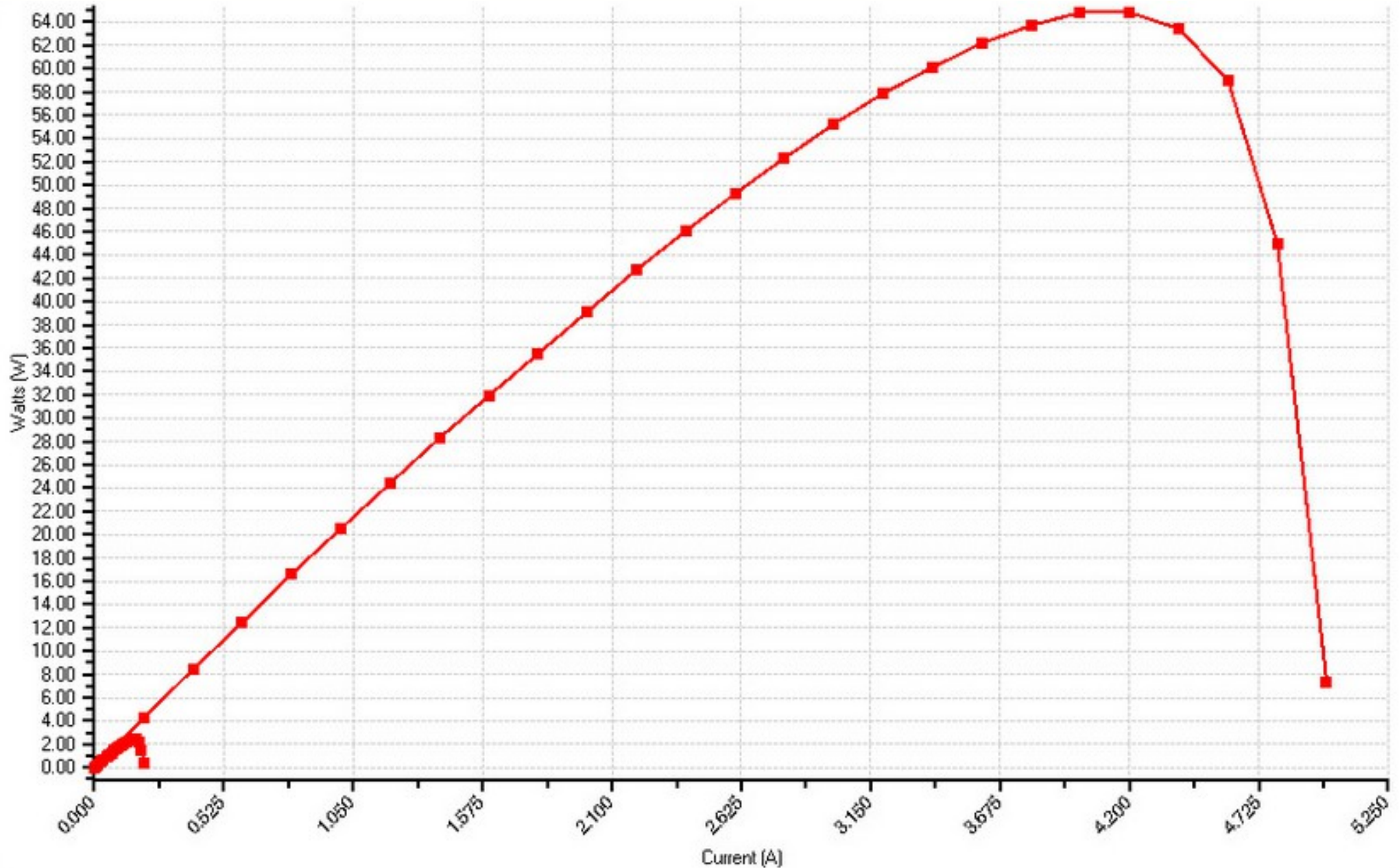
Just a panel is about \$1 per watt

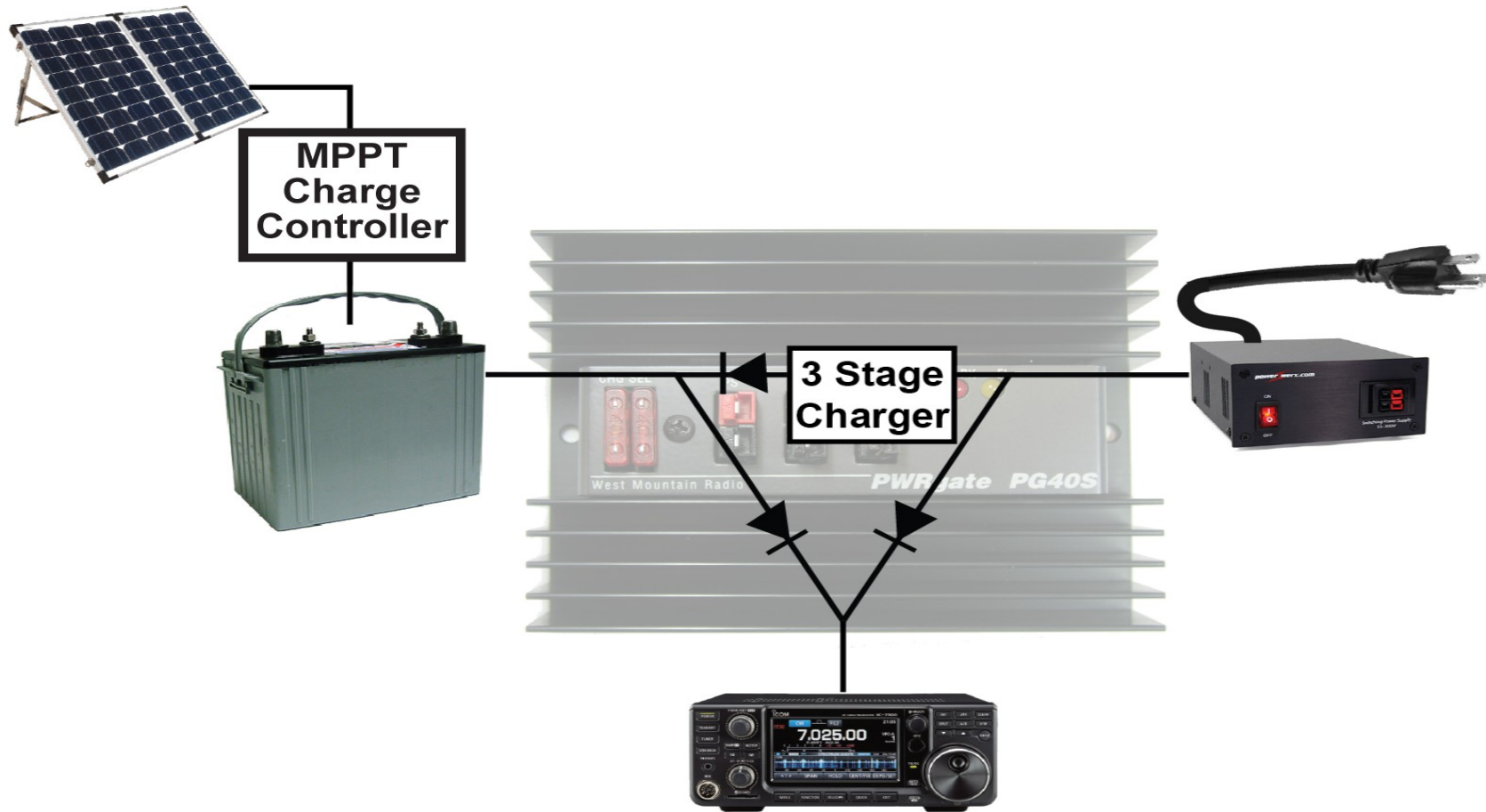
**With case/stands...
up to \$2 per watt**

Solar Power

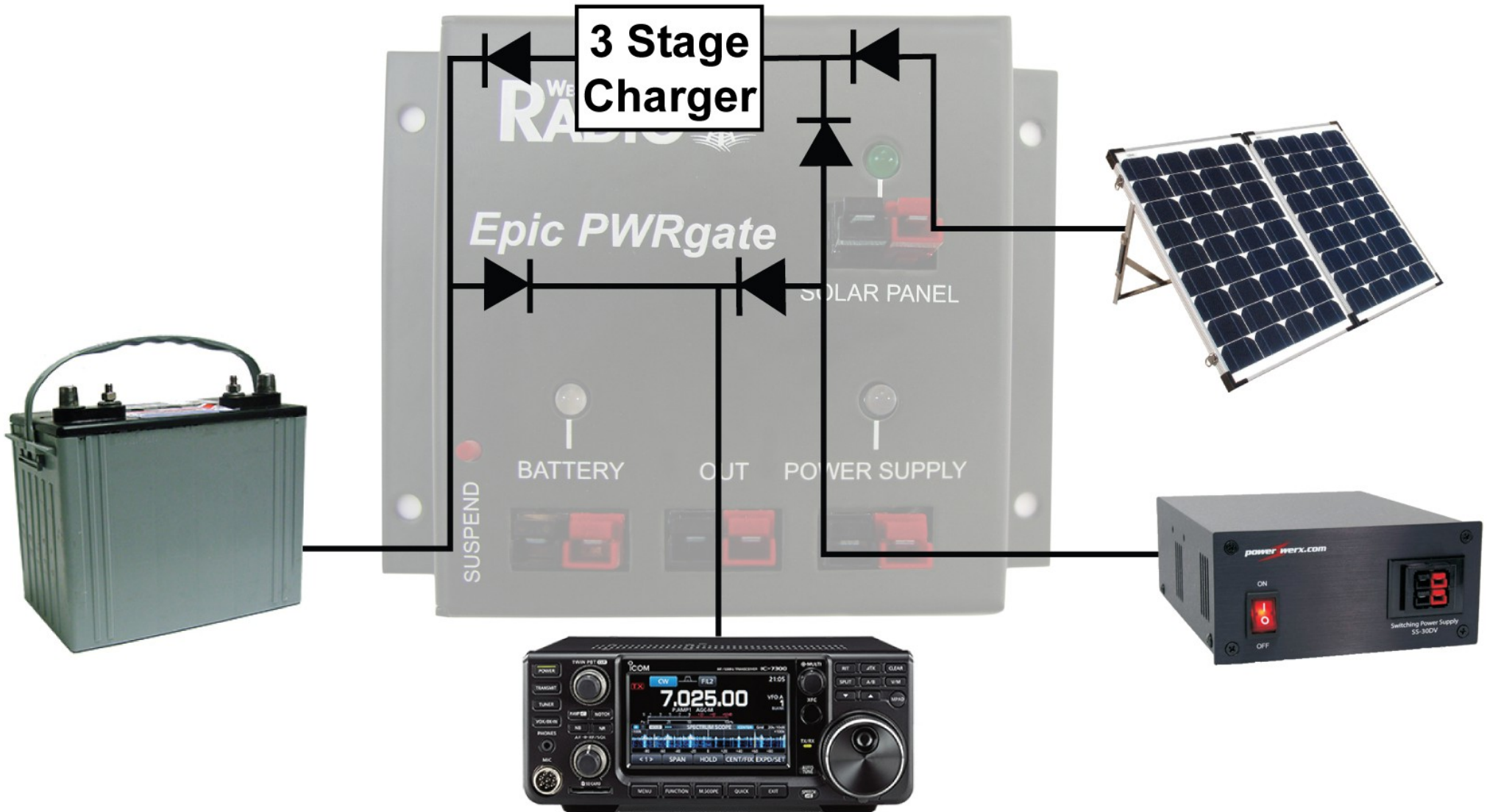


Direct vs. Indirect Sunlight

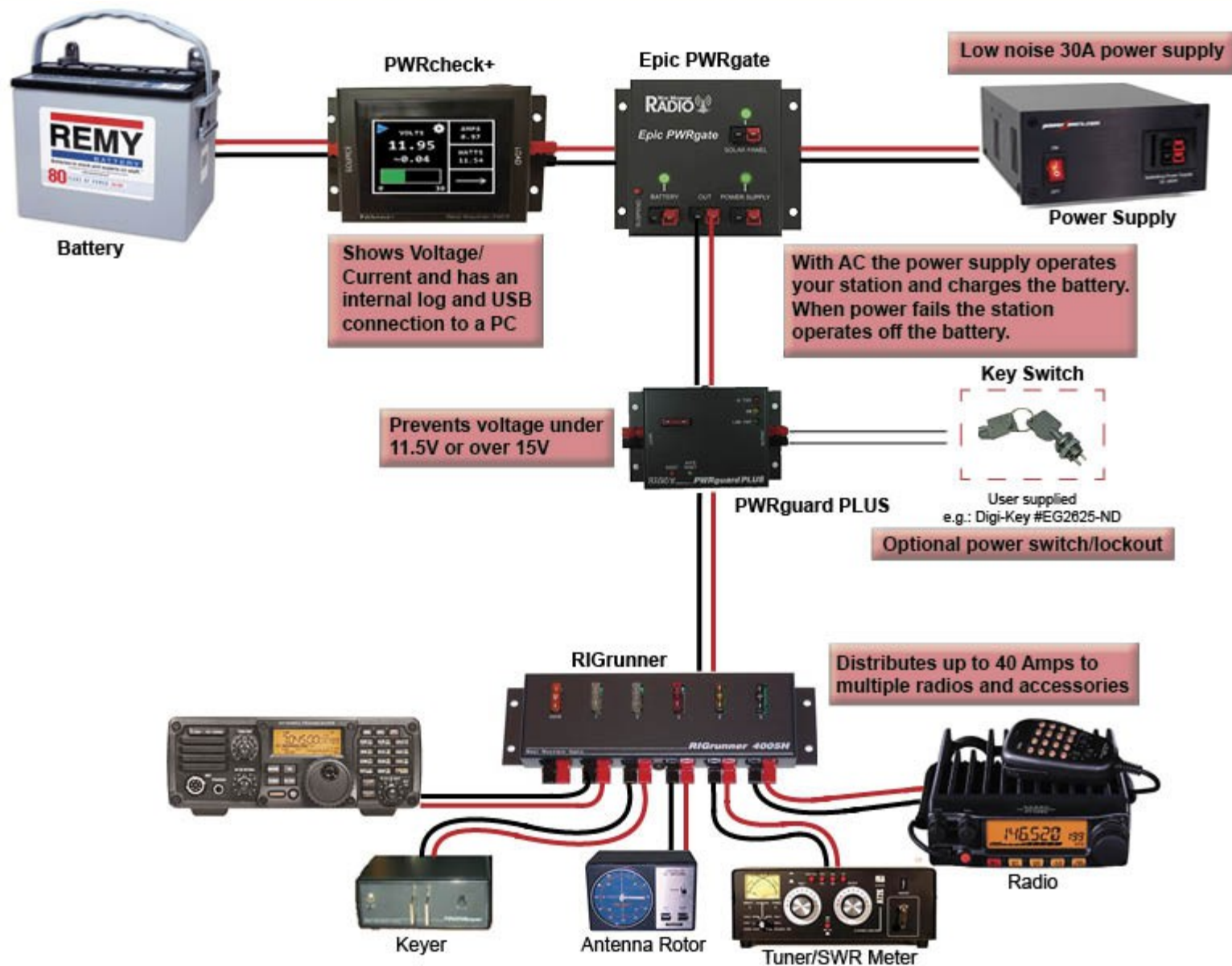




Panel Direct Configuration



Base Configuration



PWRguard+

Prevents Voltage Under
11.5V or over 15V



Power Supply



RIGrunner

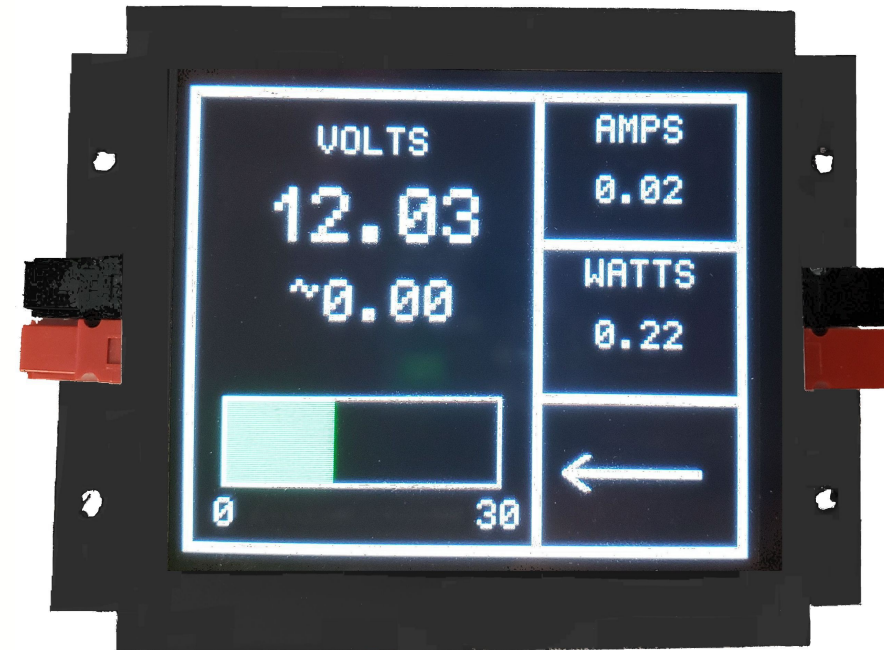
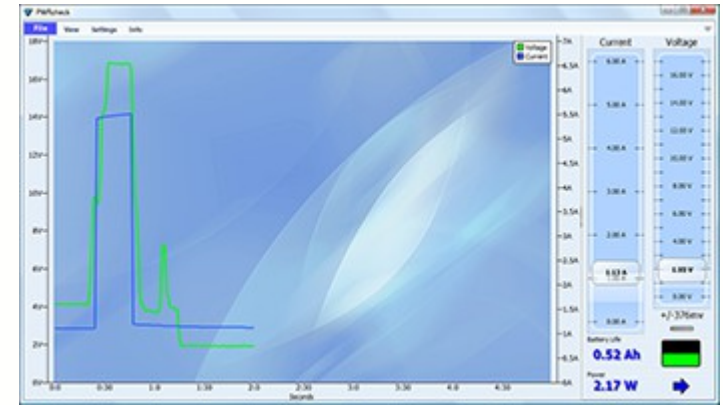
Key Switch



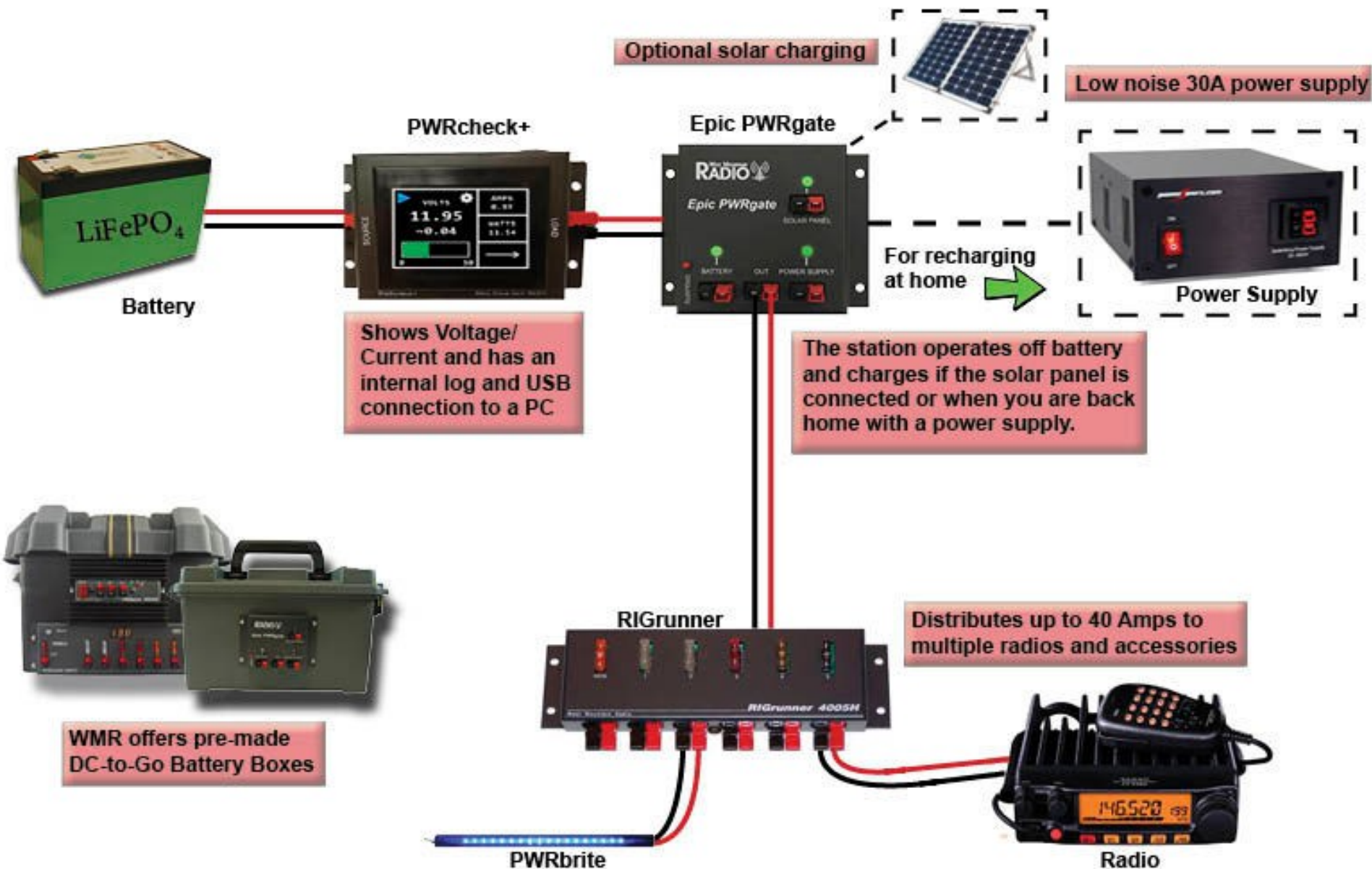
User Supplied
e.g. Digi-Key EG2625-ND

Features:

- Stores more than 100,000 data points (2 months of data)
- USB computer interface
- Up to 60V and 40A
- 8 Display formats
- Bi-directional
- High side monitoring



Field Configuration



Questions?

R WEST MOUNTAIN **RADIO**



**Visit our virtual show booth for discounts
through Tuesday
www.westmountainradio.com/show**

**Slides available at:
www.westmountainradio.com/slides
Code: DC2021**

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marks@westmountainradio.com**