



Foothills Amateur Radio Society

Batteries 101

# Agenda

- **Primary (single-use) Batteries**
  - Alkaline
  - Lithium
- **Secondary (rechargeable) Batteries**
  - Ni-Cad, NiMH
  - Lithium Ion
- **Real World Testing**
- **12v Batteries**
  - Lead Acid
  - Lithium Iron Phosphate (LiFePO<sub>4</sub>)

# Alkaline

- **Pros**
  - Very low self-discharge (10 year shelf life)
  - Ubiquitous
  - Adapters available for most HTs
- **Cons**
  - Poor high current handling
  - Single use (non-rechargeable)
  - Possibility of leakage
  - Moderate energy density



# Alkaline

- **Alkaline batteries are 1.5v**
- **AAA**
  - 500 - 1,100 mAh\*
- **AA**
  - 1,500 - 3,000 mAh\*
- **C**
  - 4,800 - 8,000 mAh\*
- **D**
  - 9,000 - 17,000 mAh\*
- **9v**
  - 350 - 600 mAh\*

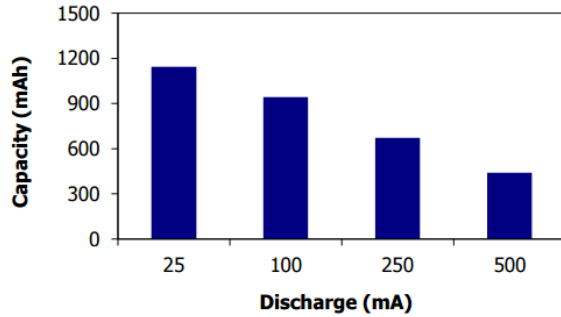


**\*500 to 25 mA discharge current**

# Alkaline (Energizer)

## Milliamp-Hours Capacity

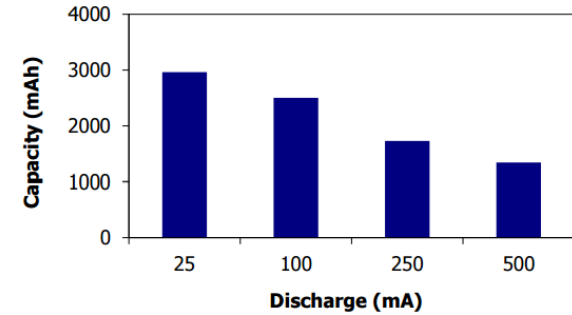
Continuous discharge to 0.8 volts at 21°C



AAA

## Milliamp-Hours Capacity

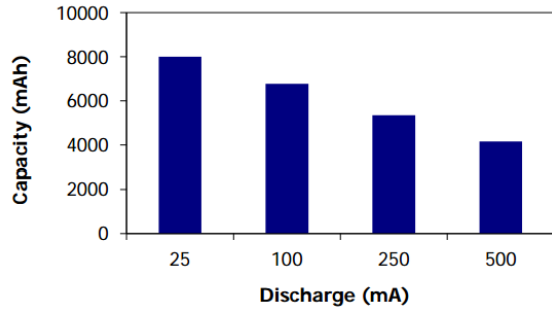
Continuous discharge to 0.8 volts at 21°C



AA

## Milliamp-Hours Capacity

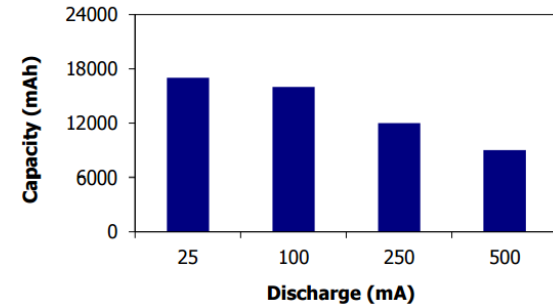
Continuous discharge to 0.8 volts at 21°C



C

## Milliamp-Hours Capacity

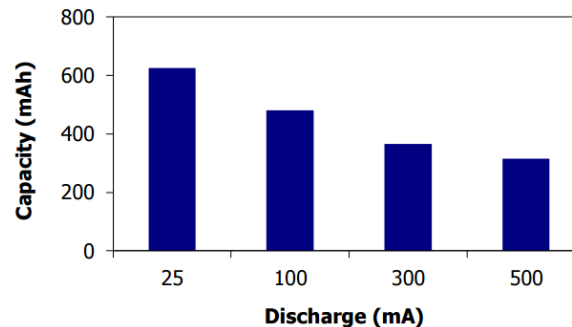
Continuous discharge to 0.8 volts at 21°C



D

## Milliamp-Hours Capacity

Continuous discharge to 4.8 volts at 21°C



9v

Source: <http://data.energizer.com/>

# Alkaline (Peukert's Law)

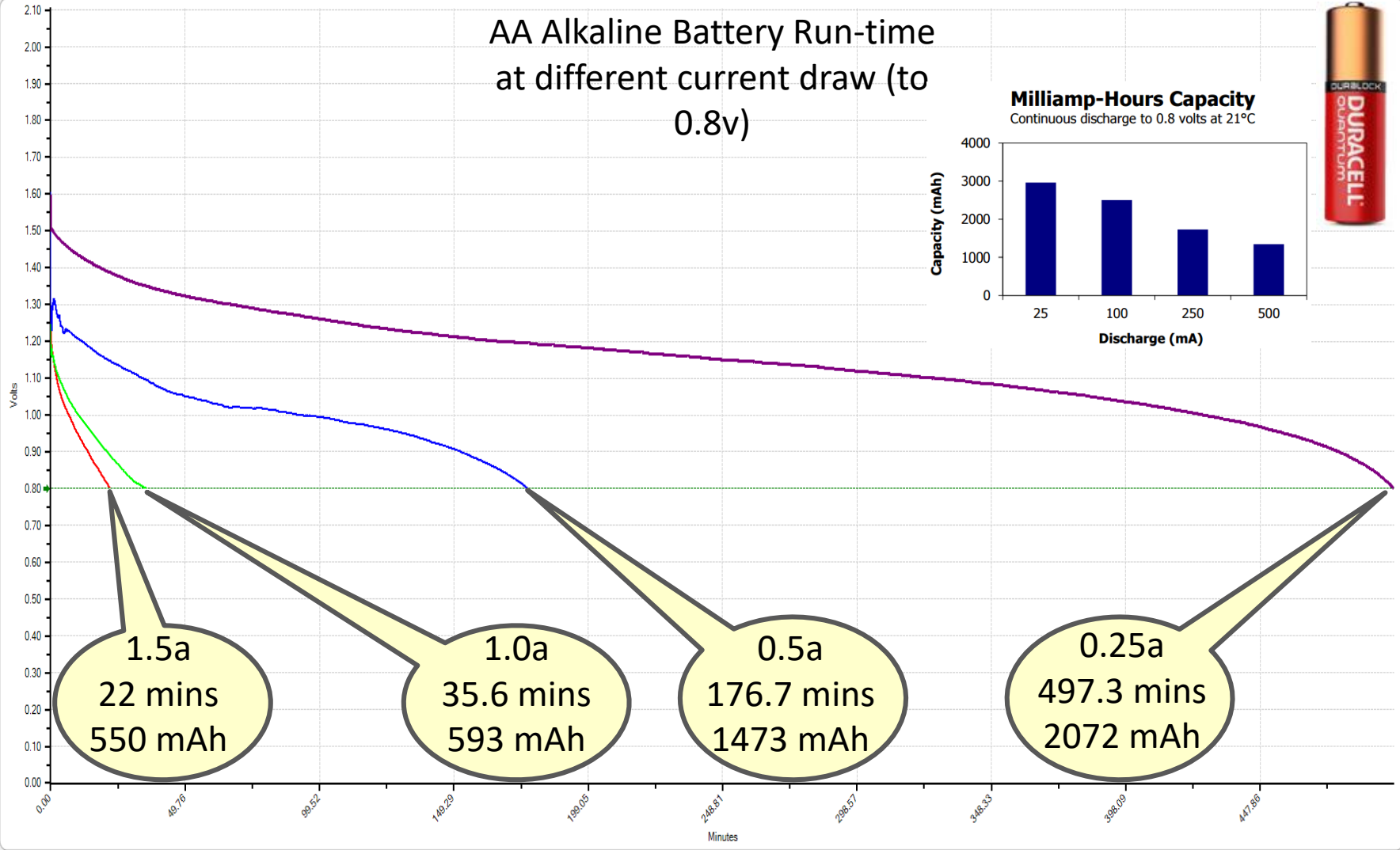
- Peukert's Law – In lead acid batteries, as the discharge current increases, the batteries available capacity decreases
- Presented by Wilhelm Peukert in 1897
- Has applications in alkaline batteries

# Alkaline (Duracell Quantum)

AA Duracell Optimum.bt2

AA Duracell Optimum: 1 Alkaline cell, 3.0 Ah @ 1.50A    AA Duracell Optimum 1a: 1 Alkaline cell, 3.0 Ah @ 1.00A    AA Duracell Optimum 0.5a: 1 Alkaline cell, 3.0 Ah @ 0.50A    AA Duracell Quantum 0.25a: 1 Alkaline cell, 3.0 Ah @ 0.25A

## AA Alkaline Battery Run-time at different current draw (to 0.8v)



Voltage  
1.16

Current  
.

AmpHr  
2.072

Watts  
.

Status  
Done

Resistance  
3.19

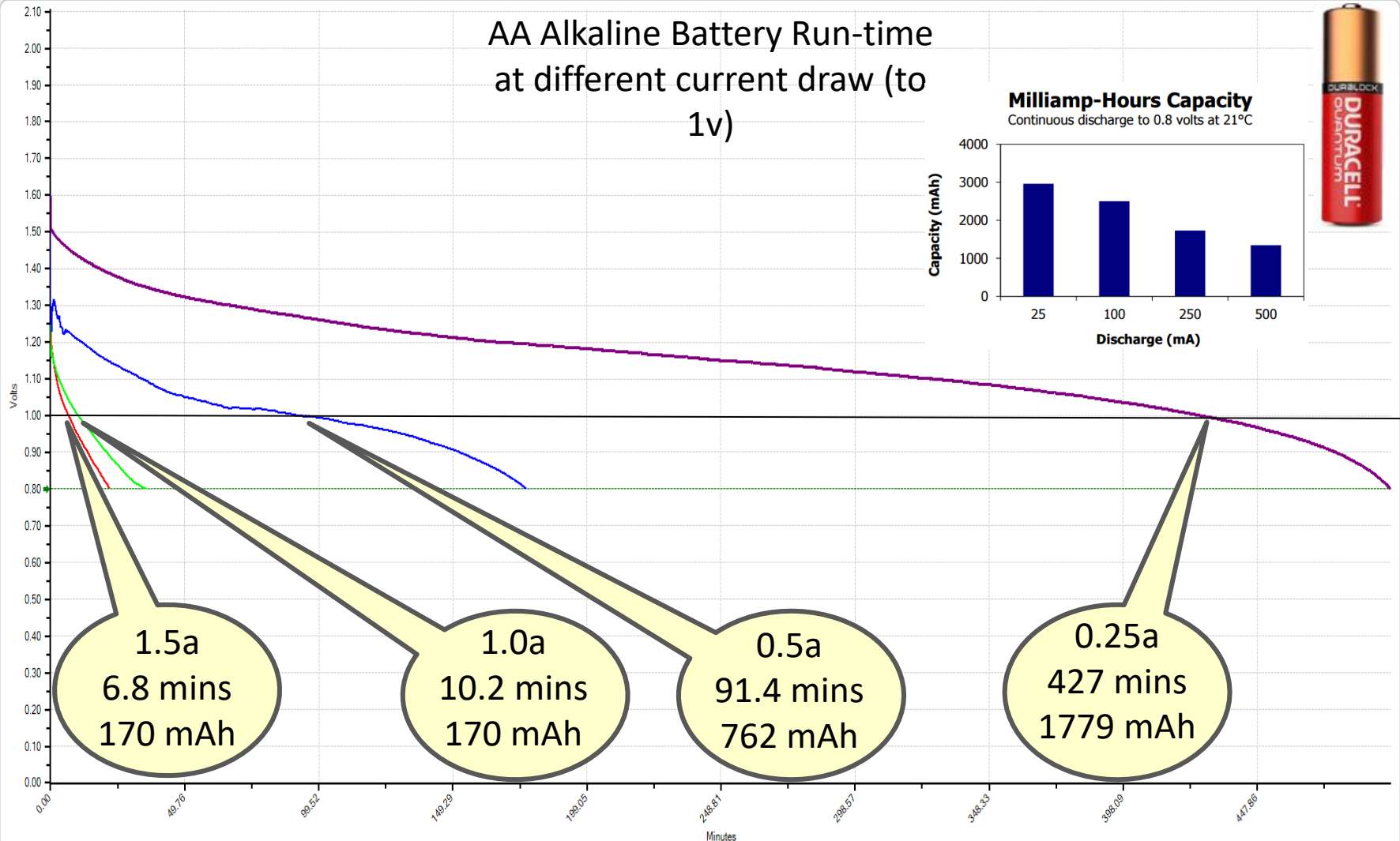
Rachel Kinoshita - KK6DAC

# Alkaline (Duracell Quantum)

AA Duracell Optimun.bt2

— AA Duracell Optimun: 1 Alkaline cell, 3.0 Ah @ 1.50A   
 — AA Duracell Optimun 1a: 1 Alkaline cell, 3.0 Ah @ 1.00A   
 — AA Duracell Optimun 0.5a: 1 Alkaline cell, 3.0 Ah @ 0.50A   
 — AA Duracell Quantum 0.25a: 1 Alkaline cell, 3.0 Ah @ 0.25A

## AA Alkaline Battery Run-time at different current draw (to 1v)



Voltage: 1.16  
 Current: .  
 AmpHr: 2.072  
 Watts: .  
 Status: Done  
 Resistance: 3.19



# Nickel Metal Hydride (NiMH)

- **Pros (Panasonic Eneloops and Tenergy Centuras)**
  - Good for high current applications
  - Rechargeable
  - Relatively long shelf life (retains 80% capacity after 1 year)
  - Will not leak
  - Adapters available for most HTs
- **Cons**
  - Moderate energy density
  - Only 1.2v vs 1.5v of alkalines



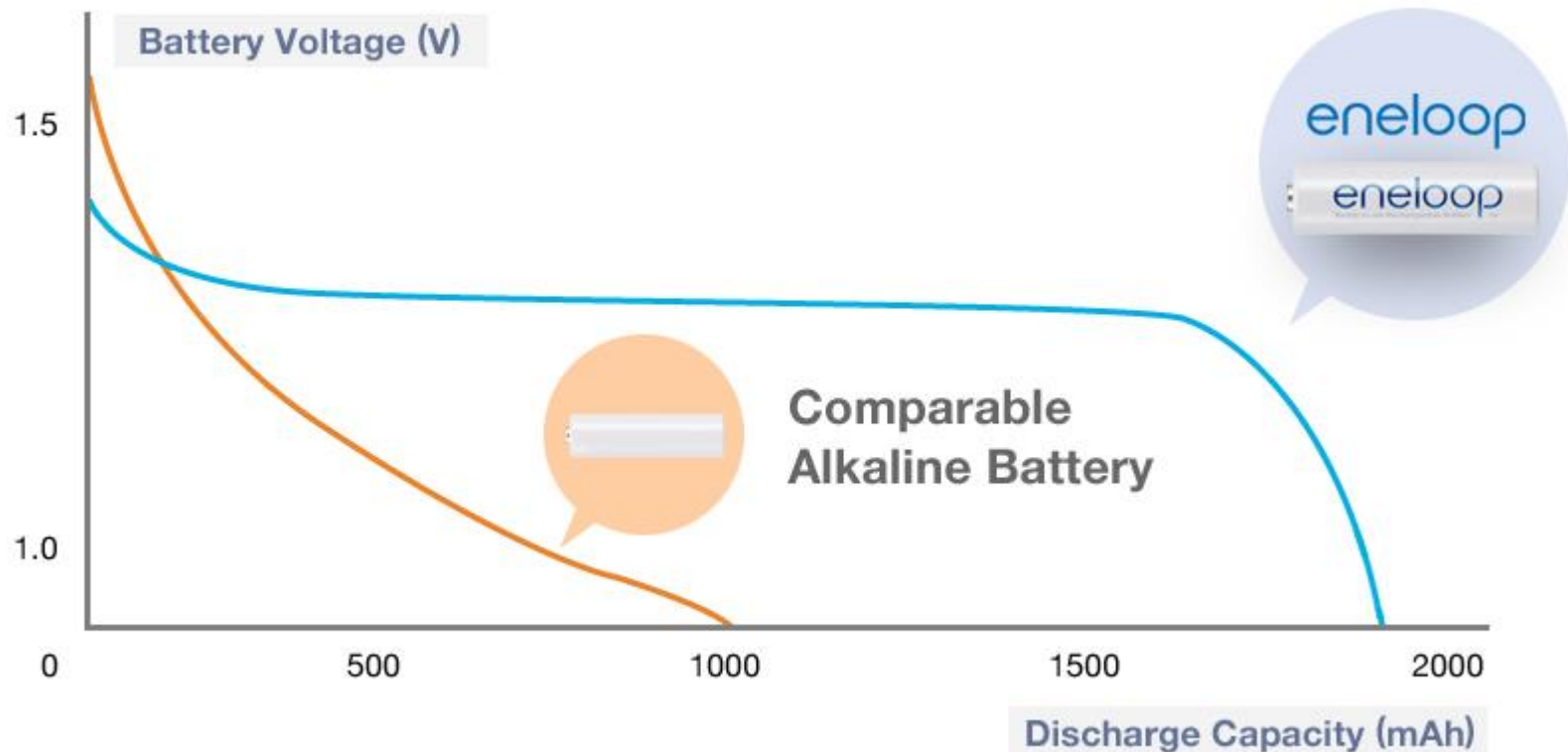
# Nickel Metal Hydride (NiMH)

- **Nickel Metal Hydride batteries are 1.2v**
- **AAA – Panasonic Eneloop Low Self-Discharge**
  - 800 mAh\*
- **AA – Panasonic Eneloop Low Self-Discharge**
  - 2,000 mAh\*
- **C – Tenergy Centura Low Self-Discharge**
  - 4,000 mAh\*
- **D – Tenergy Centura Low Self-Discharge**
  - 8,000 mAh\*
- **9v – Tenergy Centura Low Self-Discharge**
  - 200 mAh\*

**\*500 mA discharge current**

# Nickel Metal Hydride (NiMH)

500 mA (0.5A) continuous discharge



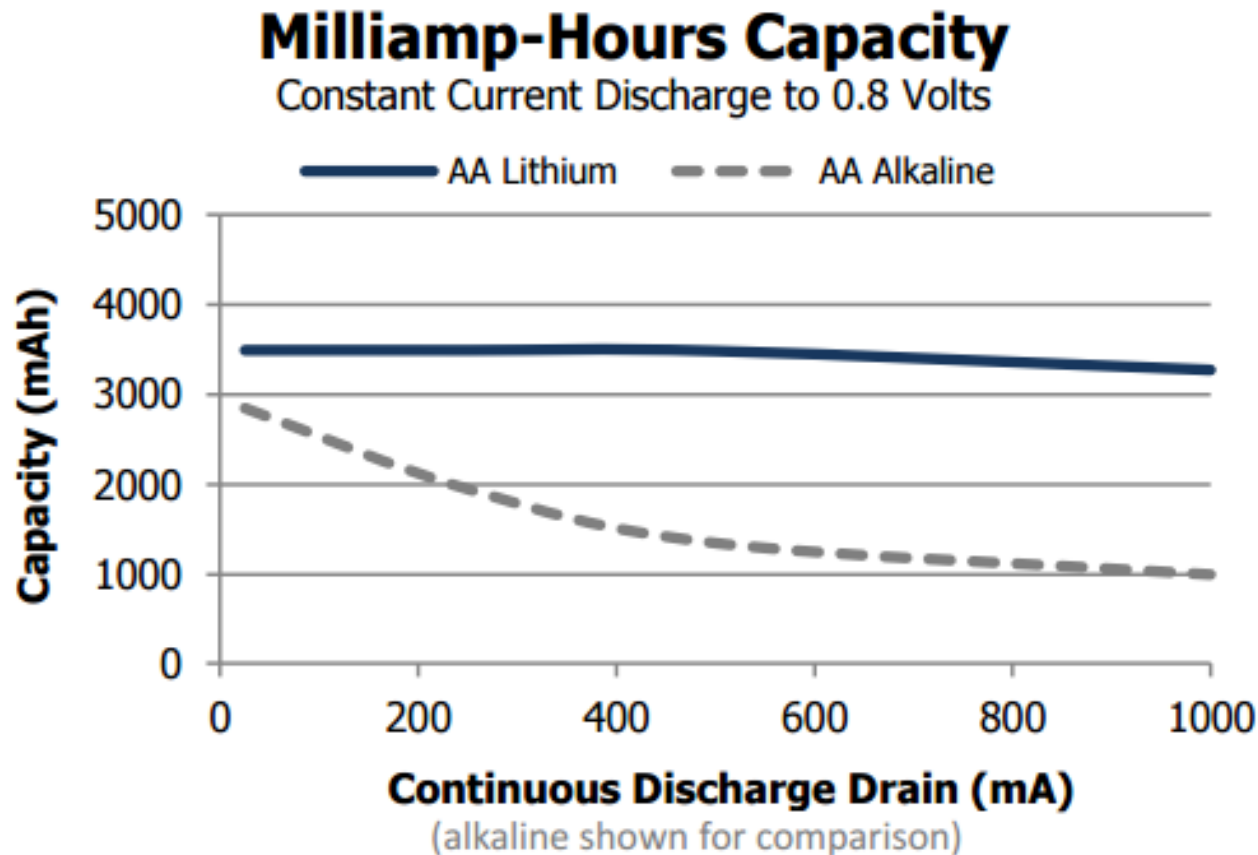
# Primary Lithium

- **Pros (Energizer Ultimate Lithium)**
  - Good for high current applications
  - Very long shelf life (20 year shelf life)
  - Will not leak
  - High energy density
  - Adapters available for most HTs
- **Cons**
  - Expensive
  - Single use (non-rechargeable)



# Primary Lithium

- Primary Lithium batteries are 1.5v
- AA – Energizer Ultimate Lithium
  - 3,500 mAh



Source: <http://data.energizer.com/>

# Rechargeable Lithium Batteries

- **First proposed in 1973**
- **First rechargeable Lithium cell developed in 1980**
- **First commercial Lithium Ion battery developed in 1991**
- **Lithium Iron Phosphate battery proposed 1996**
- **Today Lithium batteries are found in smart phones, laptop computers, tablets, Bluetooth headsets, handi-talkies (HTs), cameras, flashlights, lanterns, power tools, electric bicycles, electric cars and so on**

# Lithium Ion

- **Advantages**

- Rechargeable
- Very lightweight
- Able to provide a great deal of energy in a short amount of time
- Very low self-discharge
- Will not leak
- No outgassing
- High energy density



# Lithium Ion

- **So why are we so afraid of lithium ion batteries?**



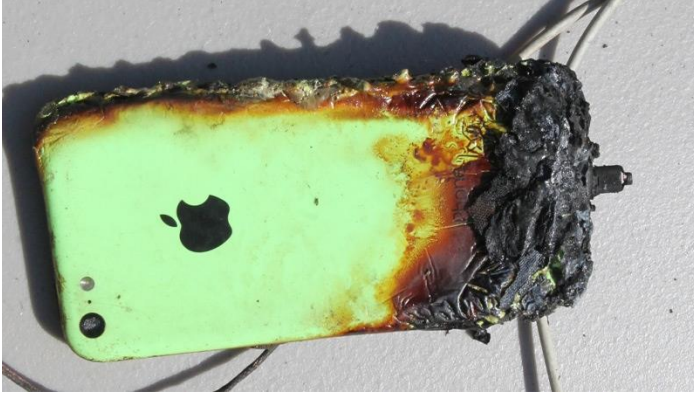
# Lithium Ion

- **So why are we so afraid of lithium ion batteries?**
- **Yes, there were those hoverboards that caught on fire**



# Lithium Ion

- So why are we so afraid of lithium ion batteries?
- Yes, there were those hoverboards that caught on fire
- And those darned mobile phones



# Lithium Ion

- **So why are we so afraid of lithium ion batteries?**
- **Yes, there were those hoverboards that caught on fire**
- **And those darned mobile phones**
- **And yes, there were even a few electric cars**



# Lithium Ion

- **So why are we so afraid of lithium ion batteries?**
- **Yes, there were those hoverboards that caught on fire**
- **And those darned mobile phones**
- **And yes, there were even a few electric cars**
  
- **Hoverboards were using poor quality batteries to keep the costs down**
- **Samsung phone batteries also had quality control issues, but keep in mind, only 0.01% caught fire**
- **5 times more likely to experience a fire in a gasoline powered vehicle**

# Lithium Ion

- **18650 batteries**
  - A little bigger than AA batteries
  - 3.7v
  - Recommend using ones with a protection circuit
  - Panasonic NCR18650B (3,400 mAh)
  - LG MJ1 18650F (3,500 mAh)
  - Used in many high output LED flashlights
  - Used in most USB Power Banks
  - Used in most laptop batteries

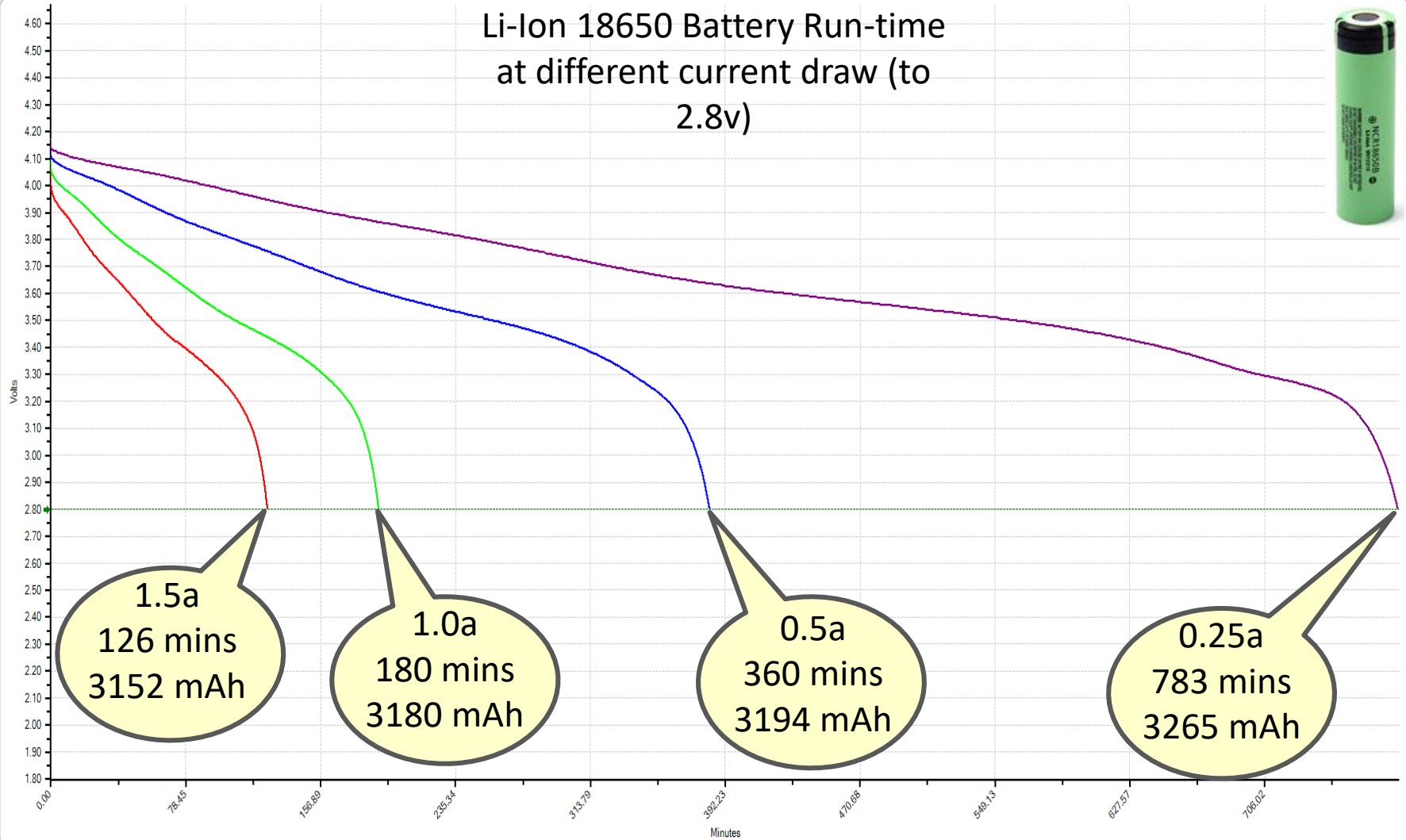


# Li-Ion 18650 (Panasonic NCR18650B)

18650.bt2

— 18650 - 1.5a: 1 Li-ion cell, 3.4 Ah @ 1.50A — 18650 - 1.0a: 1 Li-ion cell, 3.4 Ah @ 1.00A — 18650 - 0.5a: 1 Li-ion cell, 3.4 Ah @ 0.50A — 18650 - 0.25a: 1 Li-ion cell, 3.4 Ah @ 0.25A

### Li-Ion 18650 Battery Run-time at different current draw (to 2.8v)



Voltage

Current

AmpHr

Watts

Status

Resistance

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# Lithium Ion

- 18650 for your FT-60



# Test Methodology

- **West Mountain Radio Computerized Battery Analyzer (CBA) IV**
- **WMR CBA Software V2.4.16.0 with Extended License**
- **Custom (i.e. homemade) interfaces to the various battery packs**





# Test Methodology

- **Used the Multi-Discharge test using the following settings**
  - Low-Voltage cut-off: 5.5v
  - 1s steps until cut-off voltage is met
  - Three step discharge
    - 5s @ 1.6a (transmit)
    - 22s @ 0.2a (receive)
    - 33s @ 0.02a (idle)
- **All primary/single-use batteries were “fresh”**
- **All secondary/rechargeable batteries were fully charged before testing**

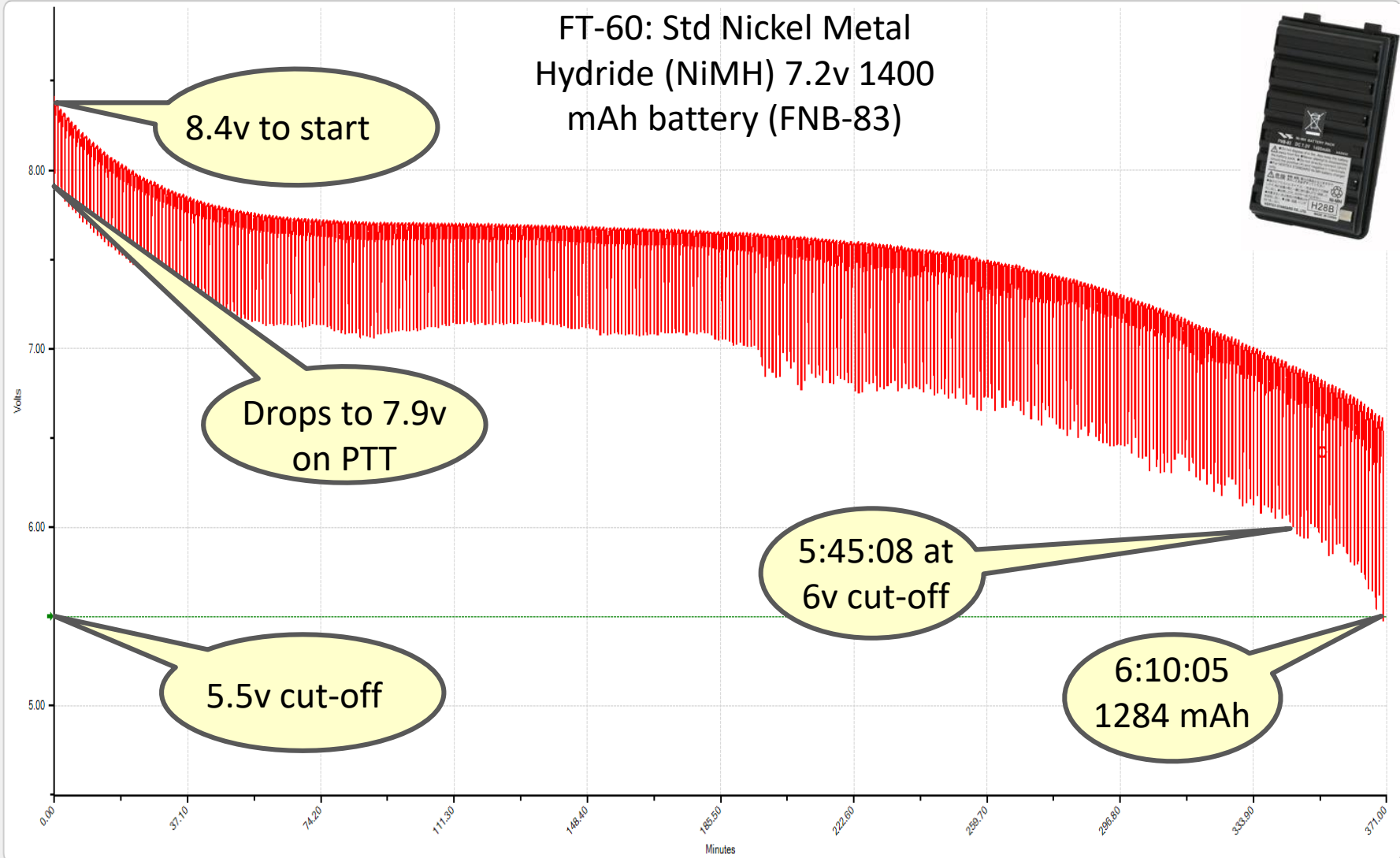
# Test Results

FT60 - NiMH 1400 mAh.bt2

✕

— FT-60 NiMH 1400 mAh: 7 NiMH cells Multiple Discharge Profile

FT-60: Std Nickel Metal  
Hydride (NiMH) 7.2v 1400  
mAh battery (FNB-83)



Voltage  
6.69

Current  
.

AmpHr  
1.284

Watts  
.

Status  
Done

Resistance  
1.84

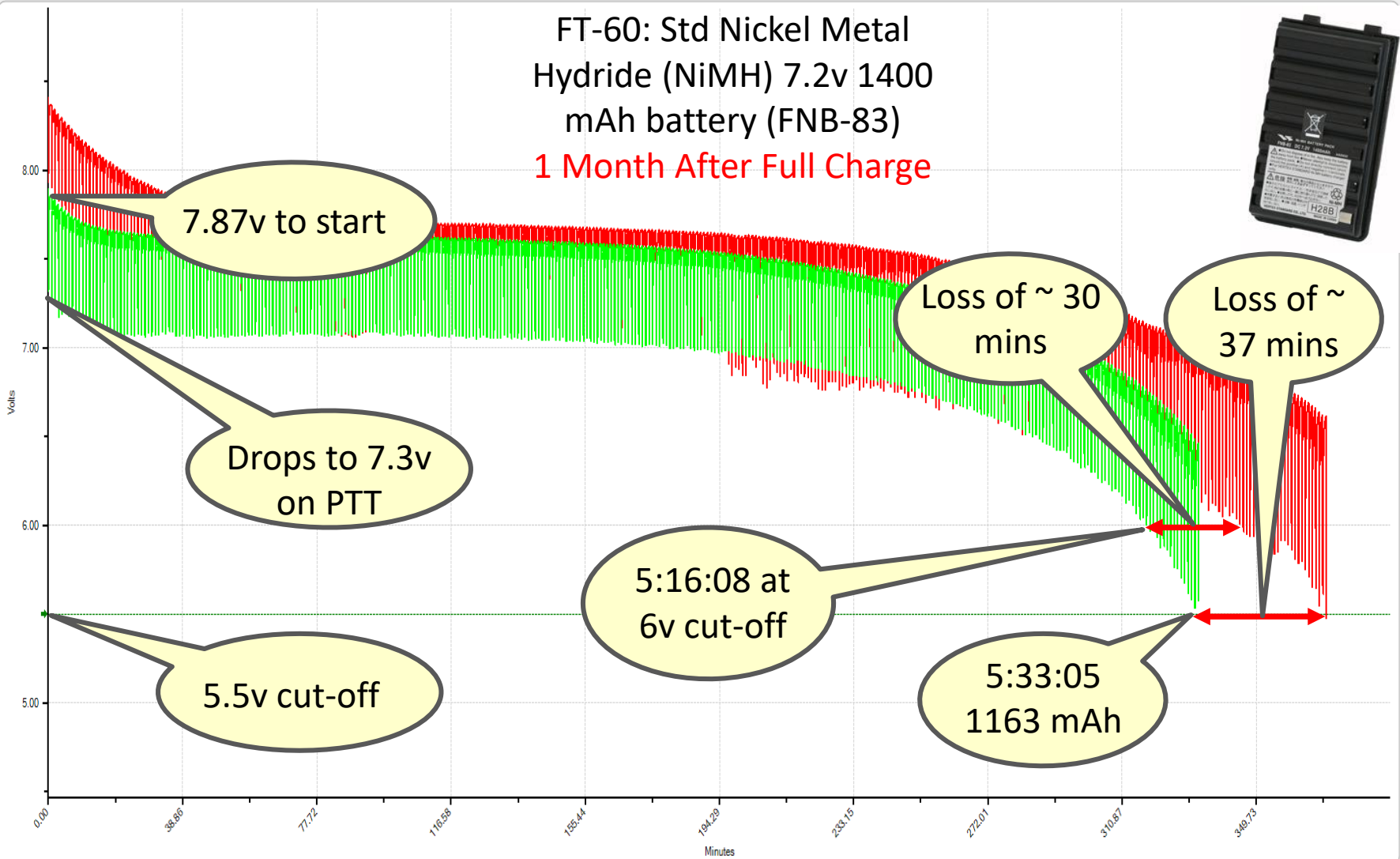
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# Test Results

FT60 - NiMH 1400 mAh.bt2

— FT-60 NiMH 1400 mAh: 7 NiMH cells Multiple Discharge Profile — FT-60 NiMH 1 Month: 7 NiMH cells Multiple Discharge Profile

FT-60: Std Nickel Metal  
Hydride (NiMH) 7.2v 1400  
mAh battery (FNB-83)  
1 Month After Full Charge



Voltage  
7.11

Current  
.

AmpHr  
1.163

Watts  
.

Status  
Done

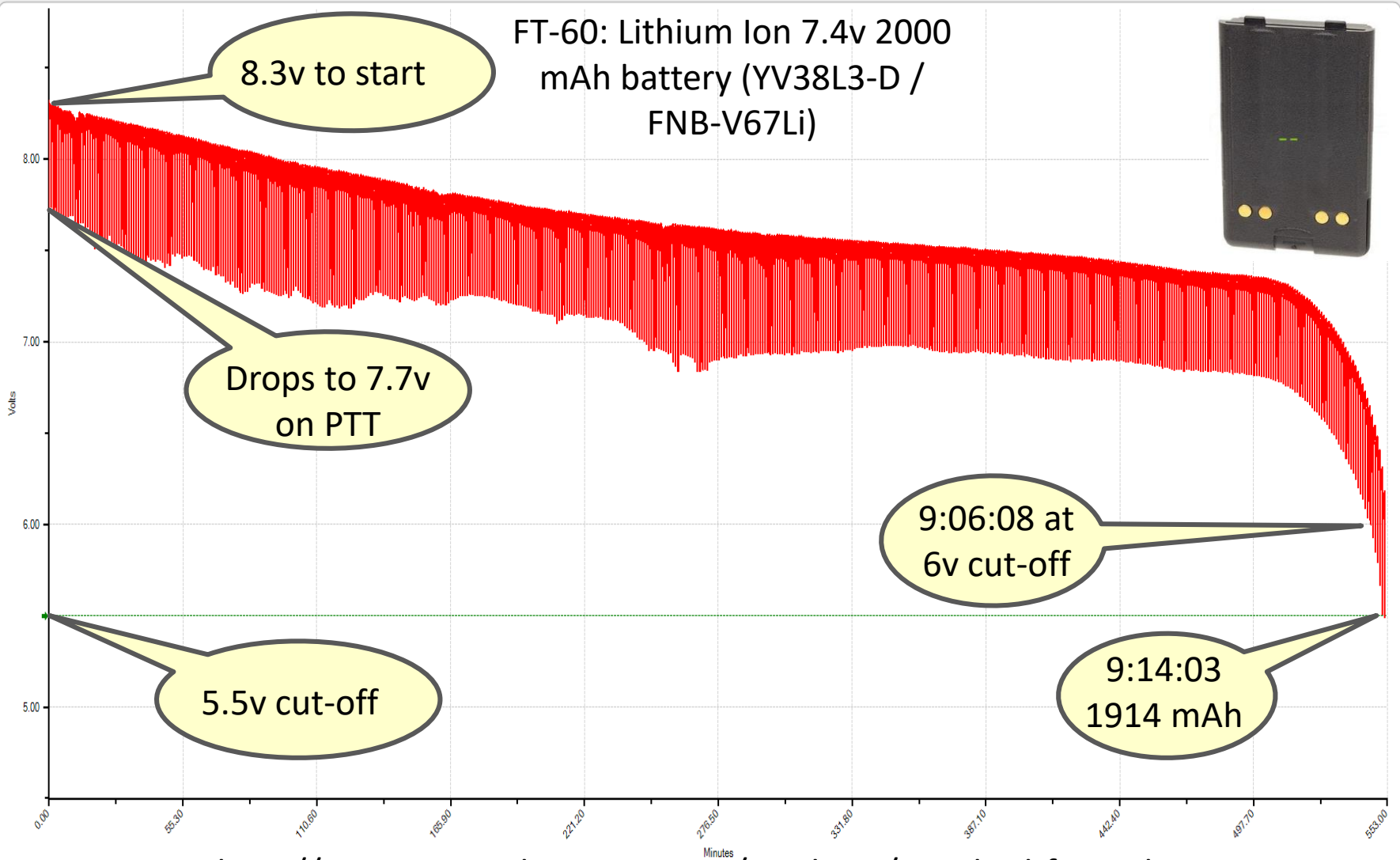
Resistance  
1.50

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# Test Results

FT60 - Li-Ion 2500 mAh.bt2

— FT-60 Li-Ion 2500 mAh: 2 Li-ion cells Multiple Discharge Profile



Voltage

6.90

Current

.

AmpHr

1.914

Watts

.

Status

Done

Resistance

2.00

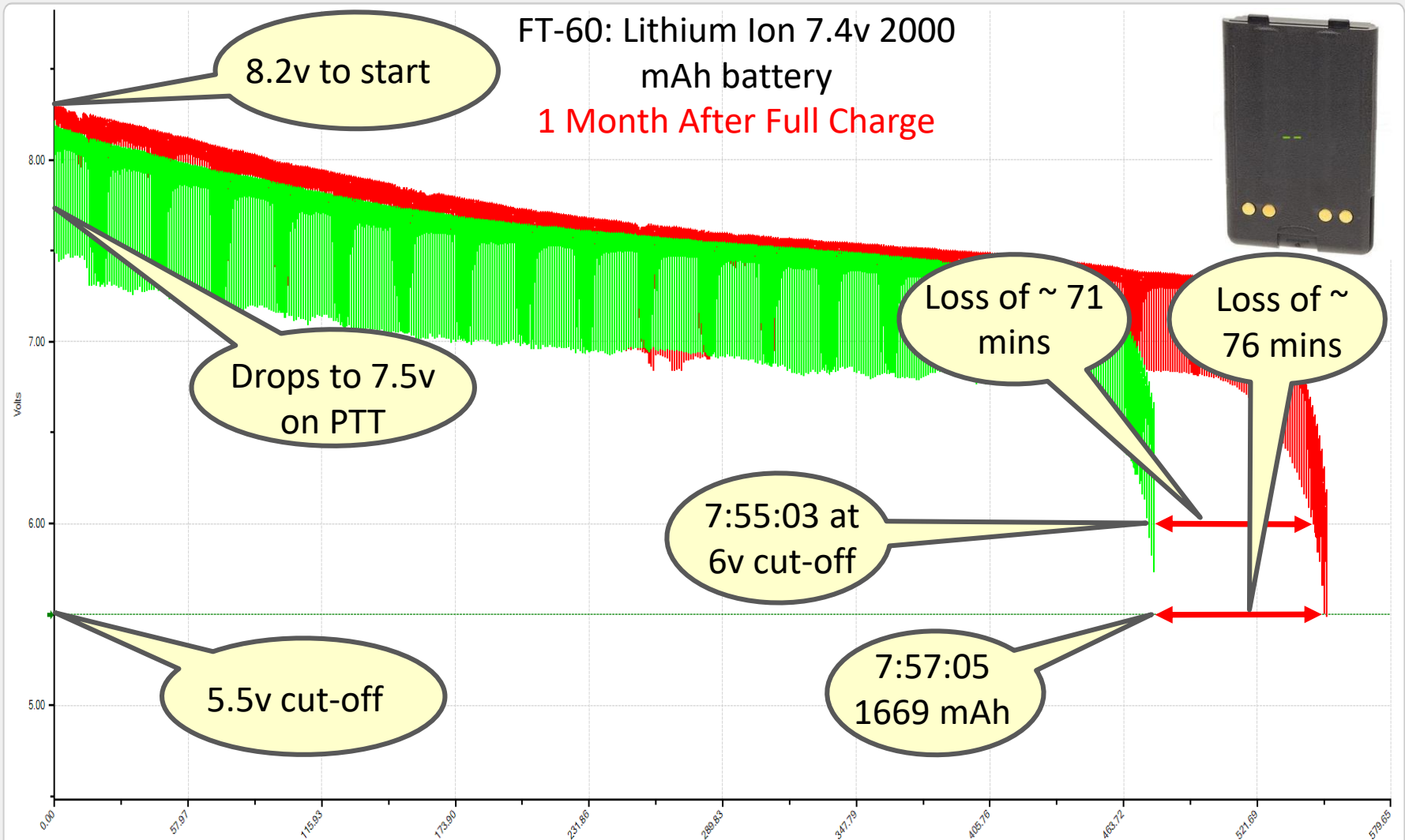
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<http://www.cutratebatteries.com/products/standard-ft-60r-battery>

# Test Results

FT60 - Li-Ion 2500 mAh.bt2

— FT-60 Li-Ion 2500 mAh: 2 Li-ion cells Multiple Discharge Profile — FT-60 Li-Ion 1 Month: 2 Li-ion cells Multiple Discharge Profile



<http://www.cutratebatteries.com/products/standard-ft-60r-battery>

# Test Results

Yaesu FT-60 Operating Manual – Page 10

## Installation of FBA-25 Alkaline Battery Case

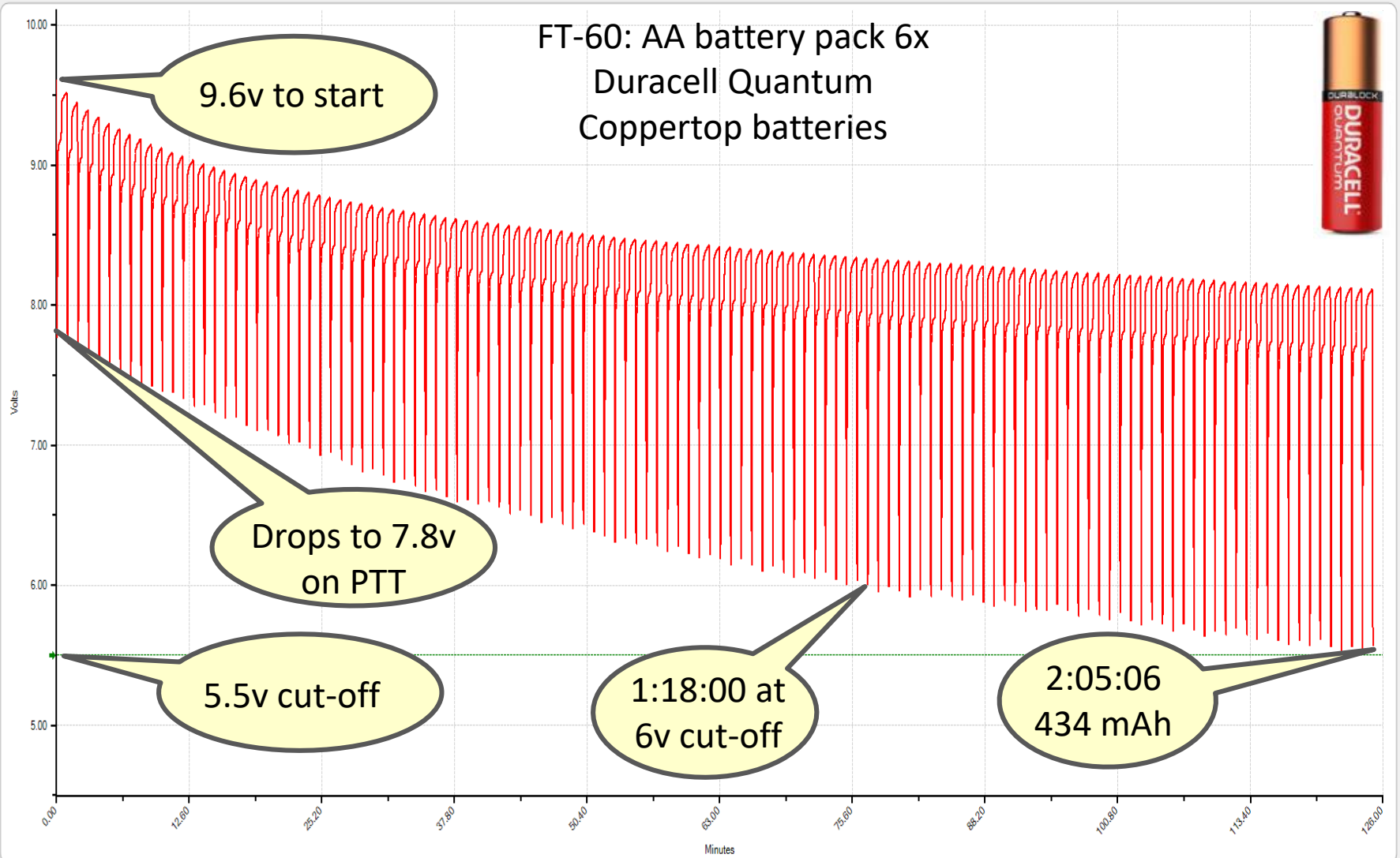
*“Note that the power output and battery life will be **much shorter** when using Alkaline AA cells. They should be considered an emergency backup power source only, for this reason”*



# Test Results

Baofeng - 1800 mAh.bt2 FT-60 NIMH 1400.bt2

FT-60 6x AA Alkaline: 6 Alkaline cells Multiple Discharge Profile



Voltage

8.60

Current

-

AmpHr

0.434

Watts

-

Status

Done

Resistance

2.60

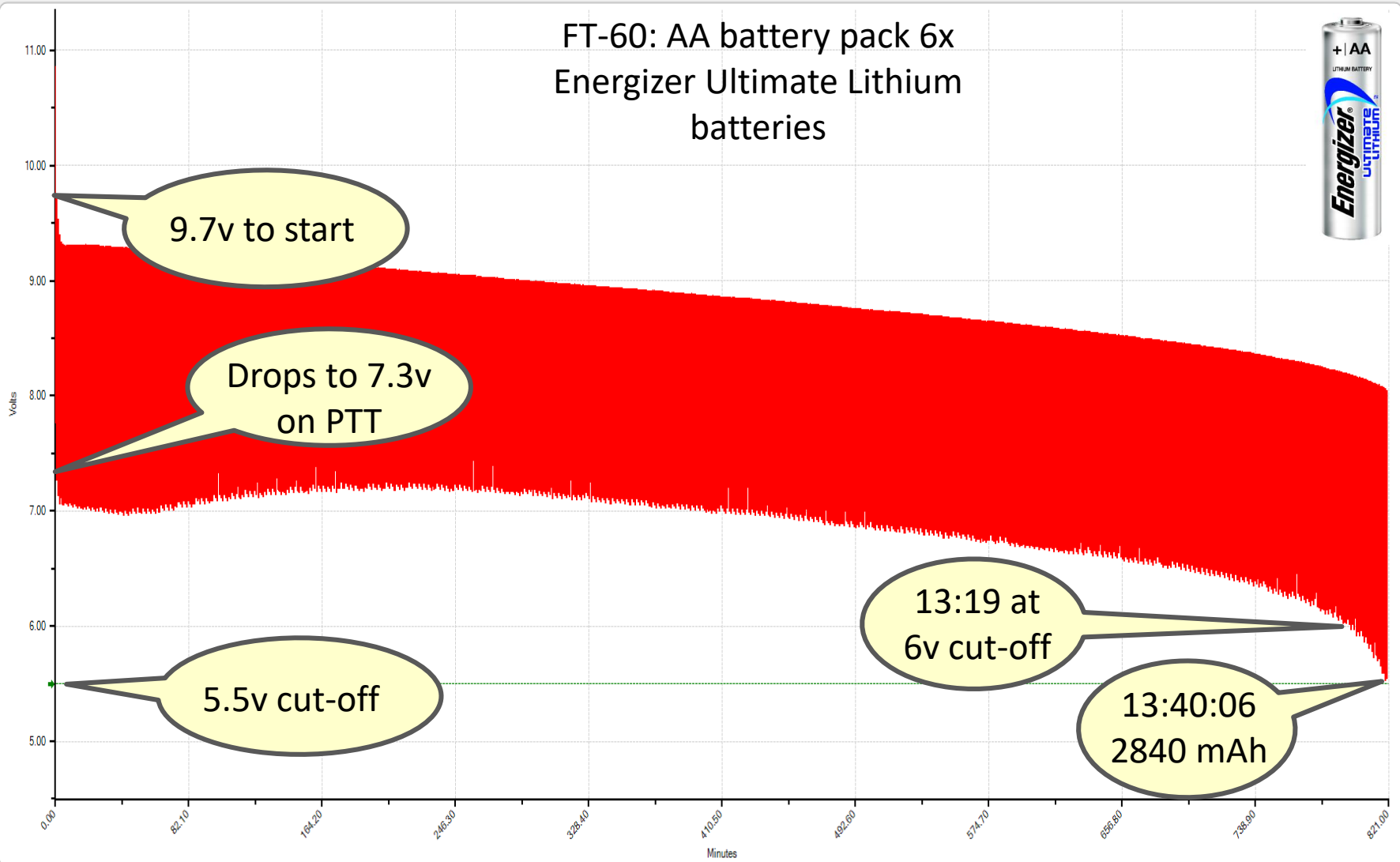
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# Test Results

FT-60 6x AA Ultimate Lithium.bt2

FT-60 6x AA Ultimate Lithium: 6 Alkaline cells Multiple Discharge Profile

## FT-60: AA battery pack 6x Energizer Ultimate Lithium batteries



Voltage  
8.85

Current  
-

AmpHr  
2.840

Watts  
-

Status  
Done

Resistance  
3.42

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# Test Results

61 alkaline batteries / \$43.00 / 57.36 oz (3.5 lbs)



==



\$9.00 / 3 oz

Alkaline: 1:18 to 6v

Lithium : 13:19 to 6v

Lithiums last 10.24x longer than Alkalines

10.24 x 6 batteries = 61

# Test Results

Yaesu FT-60 Operating Manual – Page 10

## Installation of FBA-25 Alkaline Battery Case

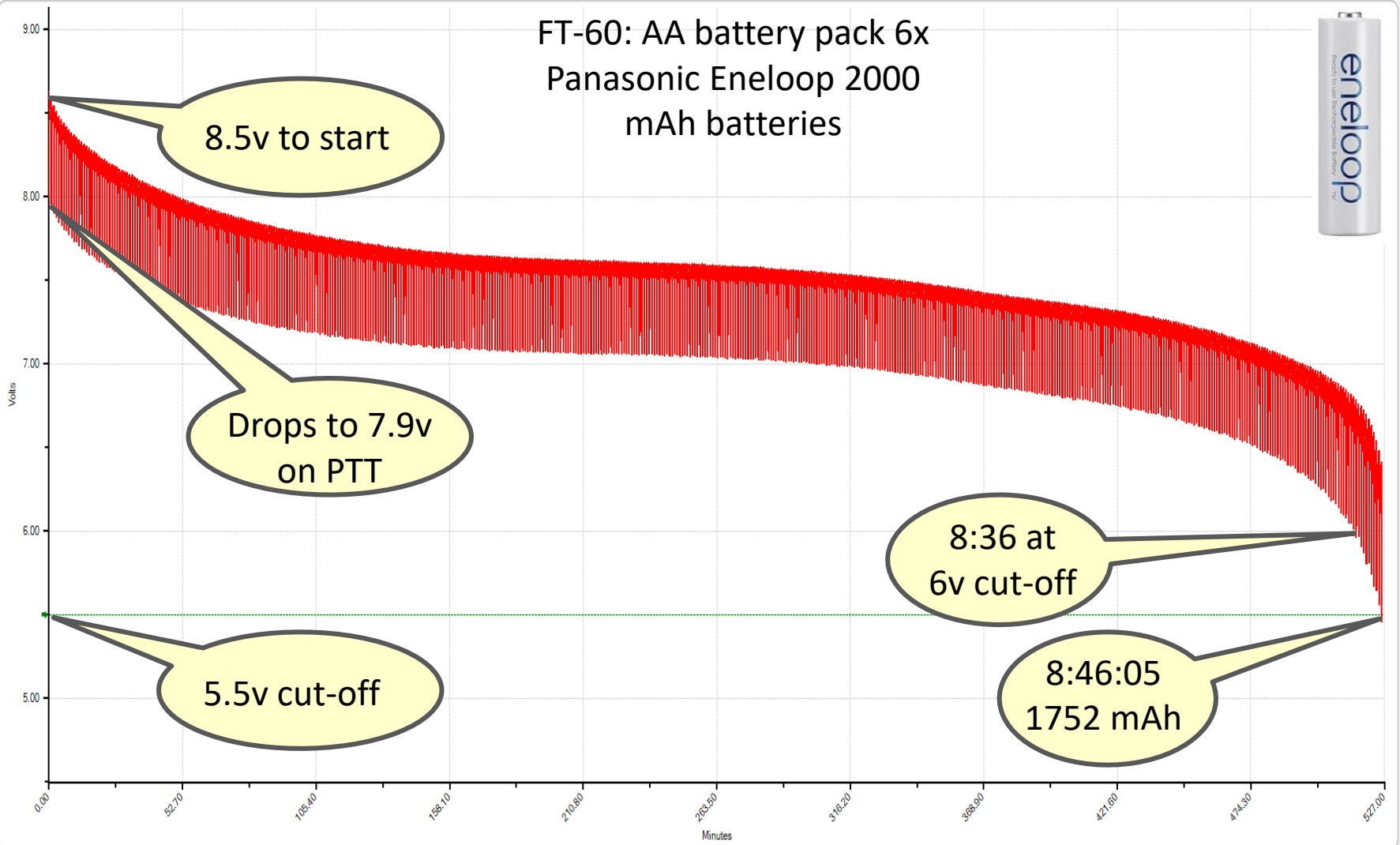
“The **FBA-25A** must not be used with rechargeable cells. The **FBA-25A** does not contain the thermal and over-current protection circuits (provided in the "FNB" series of Ni-MH Battery Packs) required when utilizing Ni-Cd or Ni-MH cells.”



# Test Results

Baofeng - 6x Eneloop: 6 NiMH cells Multiple Discharge Profile

FT-60: AA battery pack 6x  
Panasonic Eneloop 2000  
mAh batteries



Voltage  
7.16

Current  
-

AmpHr  
1752

Watts  
-

Status  
Done

Resistance  
2.12

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# Test Results

40 alkaline batteries / \$27.77 / 37 oz (2.3 lbs)



\$12.00 / 2.7 oz

Alkaline: 1:18 to 6v

NiMH: 8:36 to 6v

NiMHs last 6.62x longer than Alkalines

6.62 x 6 batteries = 39.7

# Test Results

40 alkaline batteries / \$27.77 / 37 oz (2.3 lbs)



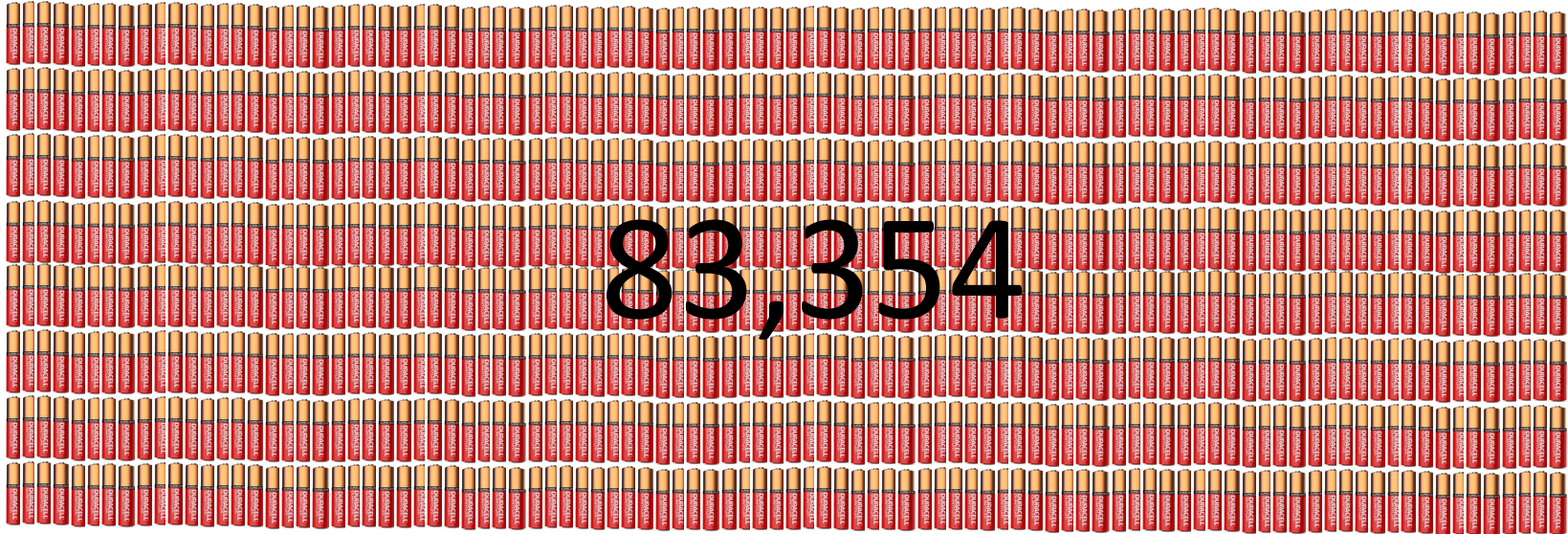
But wait, the Eneloop's are rechargeable up to 2100 times



\$12.00 / 2.7 oz

# Test Results

\$58,320 / 2.43 tons



==



\$12.00 / 2.7 oz  
(plus \$50.40 to recharge then  
2100 times)

- It takes 20Wh or 0.02 kWh to charge one Eneloop
- All six would take 0.12 kWh
- We pay an average of \$0.20 per kWh
- Charging all six batteries costs less than 2 ½ ¢
- To recharge them 2100 times would cost \$50.40

# Test Results

\$12,206 / 254 lbs



\$12.00 / 2.7 oz

(plus \$50.40 to recharge then 2100 times)

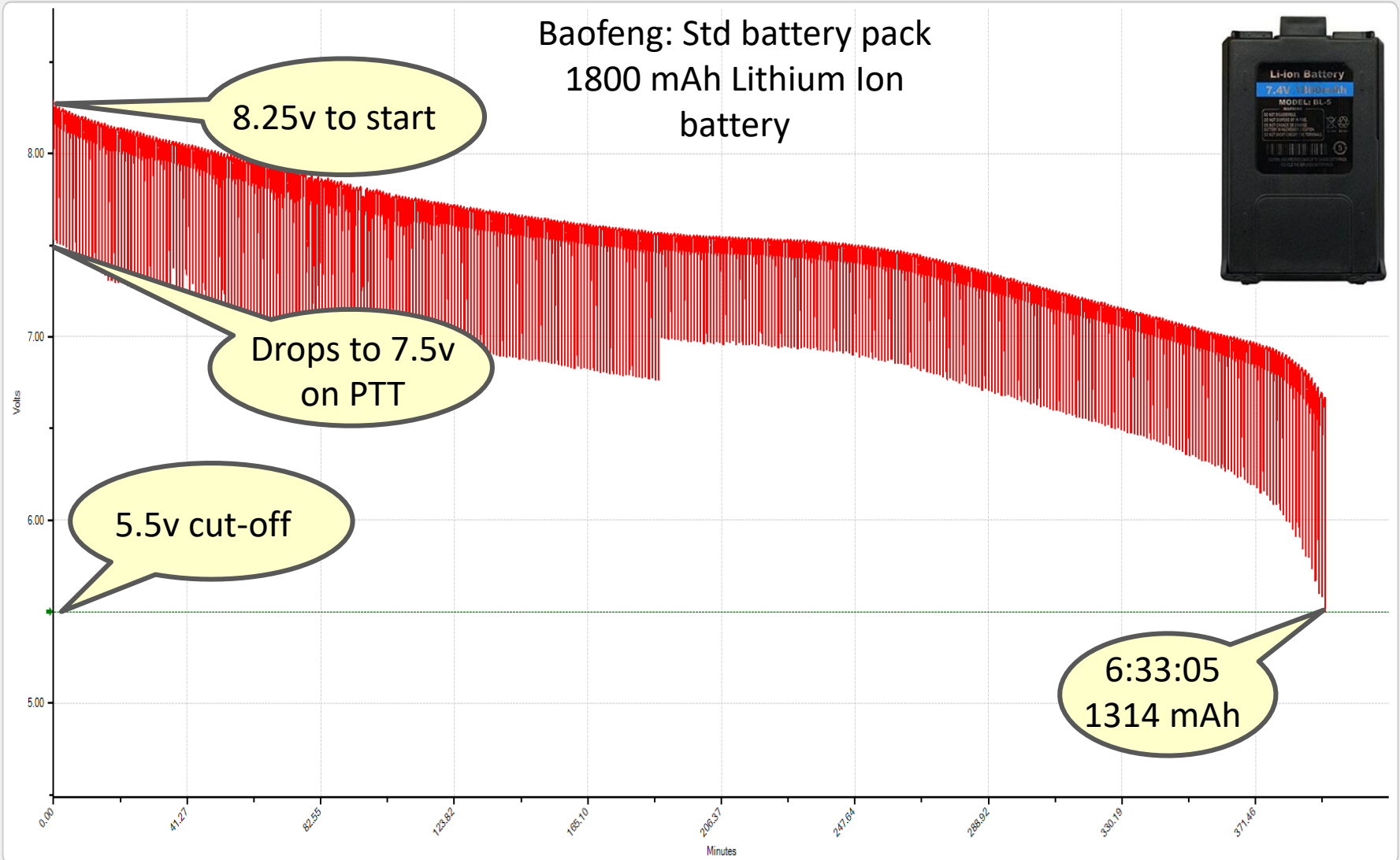


- It takes 20Wh or 0.02 kWh to charge one Eneloop
- All six would take 0.12 kWh
- We pay an average of \$0.20 per kWh
- Charging all six batteries costs less than 2 ½ ¢
- To recharge them 2100 times would cost \$50.40

# Test Results

Baofeng - 1800 mAh.bt2

Baofeng 1800 mah: 2 Li-ion cells Multiple Discharge Profile



Voltage

Current

AmpHr

Watts

Temp

Status

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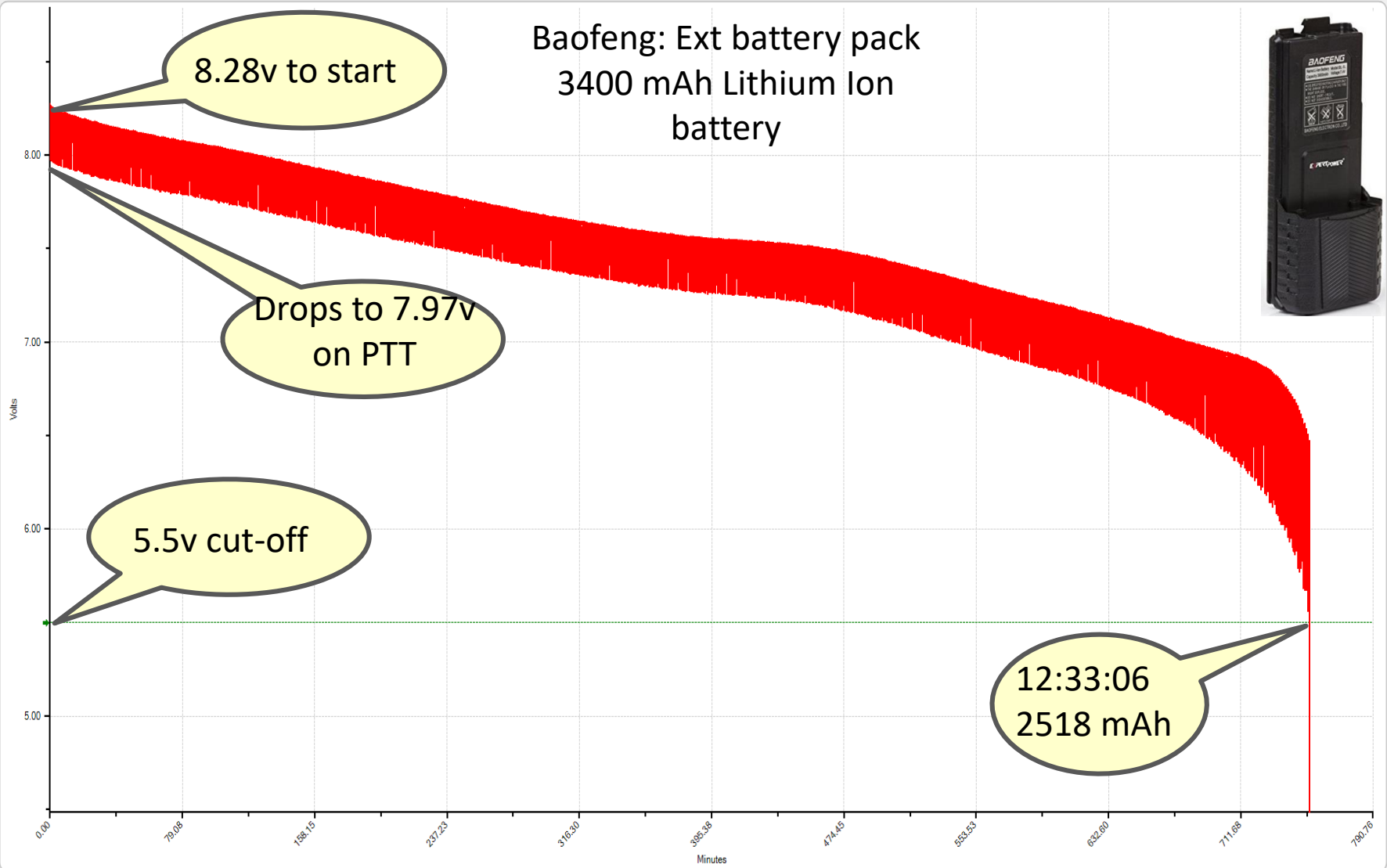
40



# Test Results

Baofeng - 3400 mAh.bt2

Baofeng - 3400 mAh: 2 Li-ion cells Multiple Discharge Profile



Voltage  
Current  
AmpHr  
2.518  
Watts  
Temp  
Status



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# Test Results

Baofeng BL-5 AA Battery Pack  
Uses 5x AA alkaline batteries (7.5v)  
plus an included dummy cell or 6x  
AA NiMH batteries (7.2v)



**BAOFENG TECH** The AA Battery Pack will work with all styles of AA Batteries:  
Depending on the AA Battery will determine how to use:  
**Normal Alkaline AA Batteries:**  
Use 5 AA Alkaline and 1 Dummy AA (included)  
*If you use 6 AA Alkaline or Zinc Carbon cells, the receiver will work but the radio won't transmit it is not recommended to use 6 Alkaline Batteries*  
**NiMH / NiCD / Rechargeable AA Batteries:**  
Use 6 AA NiMH/ NiCD/ Rechargeable Batteries

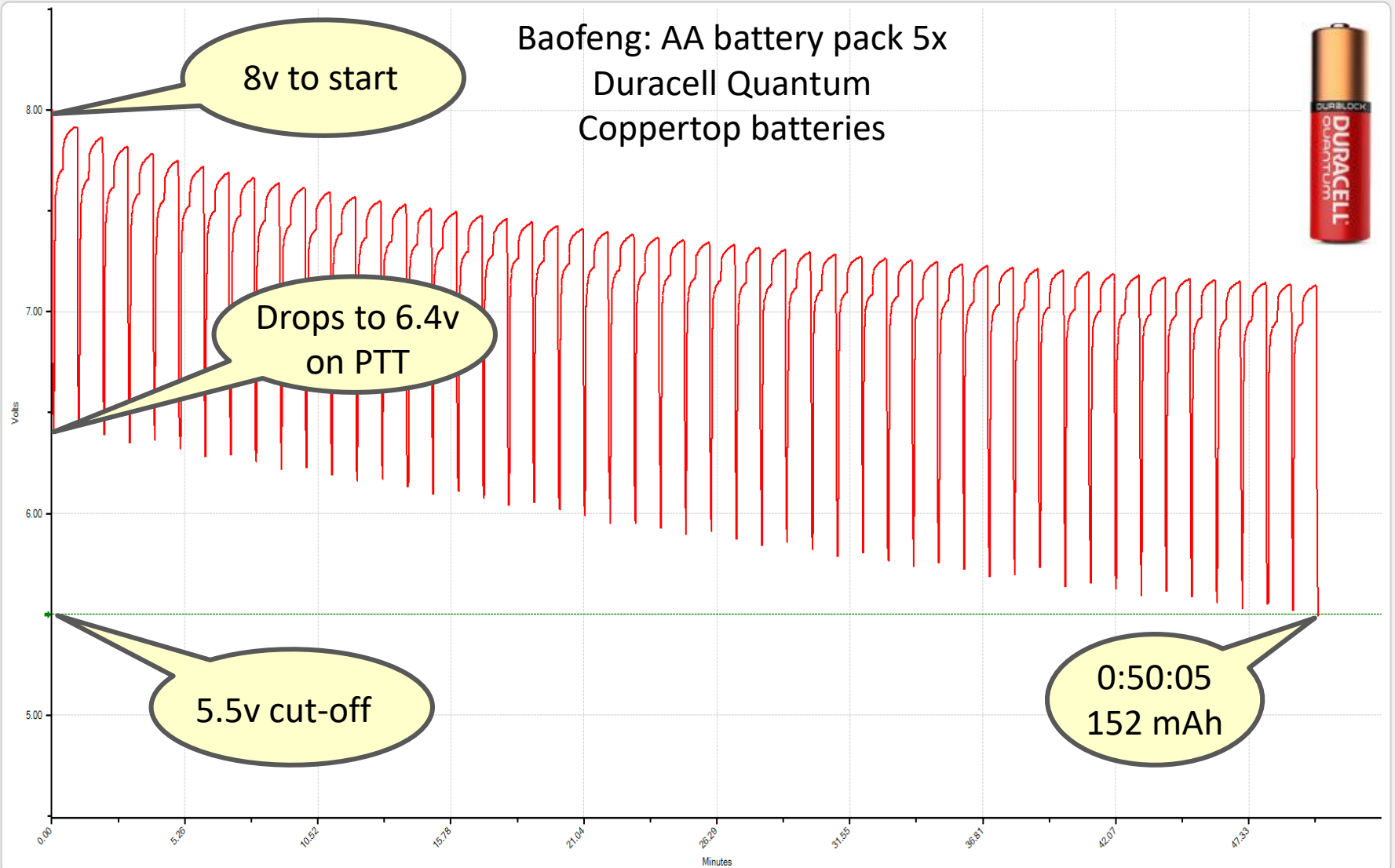


Unlike the FT-60 which can handle voltages from 9v to 6v, a Baofeng won't transmit if the battery voltage is higher than about 8v.

# Test Results

AA-Duracell-5x-Baofeng.bt2

Baofeng Alkaline: 5 Alkaline cells Multiple Discharge Profile



Voltage  
Current  
AmpHr  
Watts  
Temp  
Status

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# Test Results

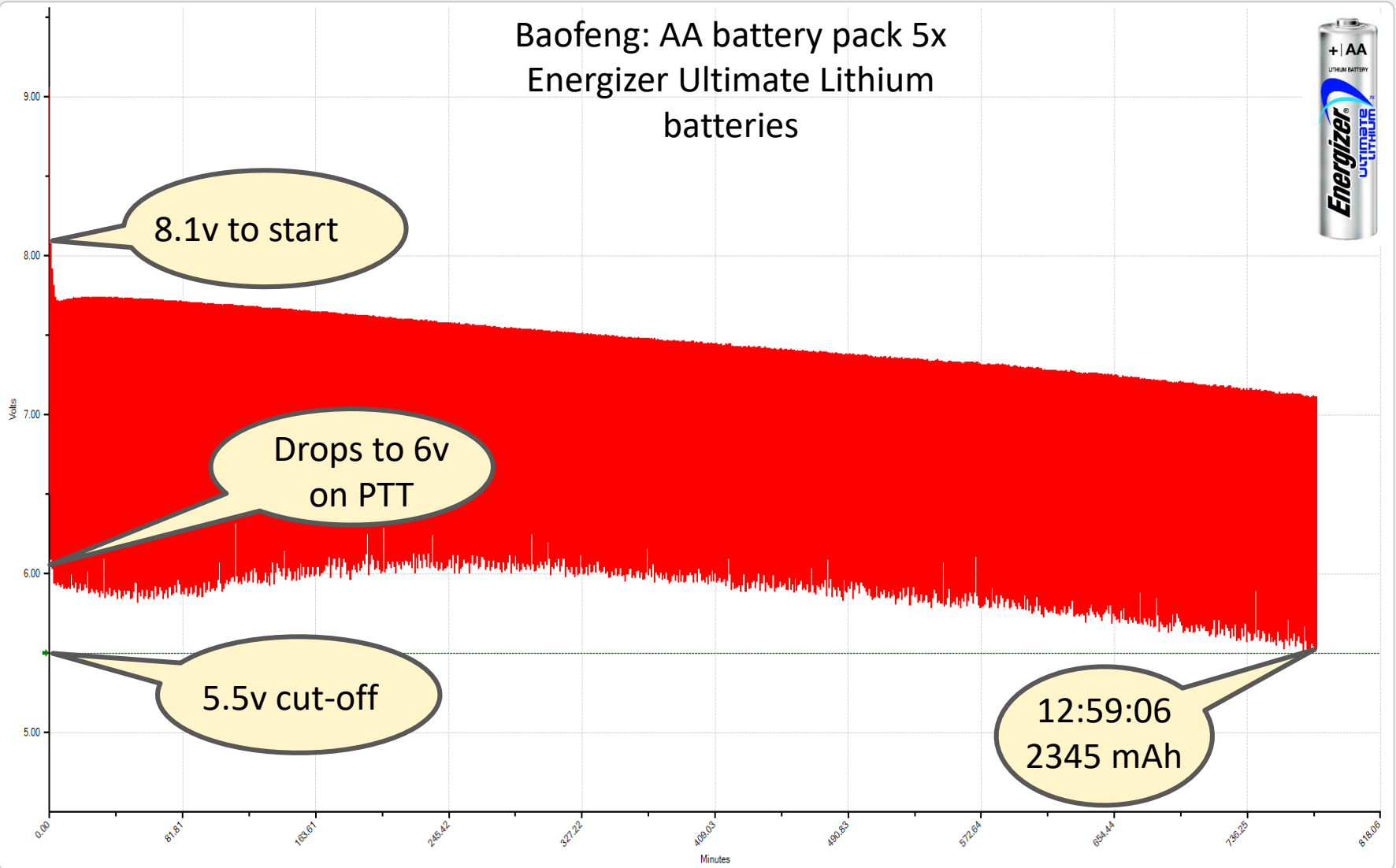
rgizer-Ultimate-Lithium-5x-Baofe

Baofeng - Energizer-Lith: 5 Alkaline cells Multiple Discharge Profile

## Baofeng: AA battery pack 5x Energizer Ultimate Lithium batteries



Voltage  
Current  
AmpHr  
Watts  
Temp  
Status



# Test Results

78 alkaline batteries / \$54.60 / 73.32 oz (4.6lbs)



\$7.50 / 2.5 oz



Alkaline: 0:50 to 6v

Lithium : 12:59 to 6v

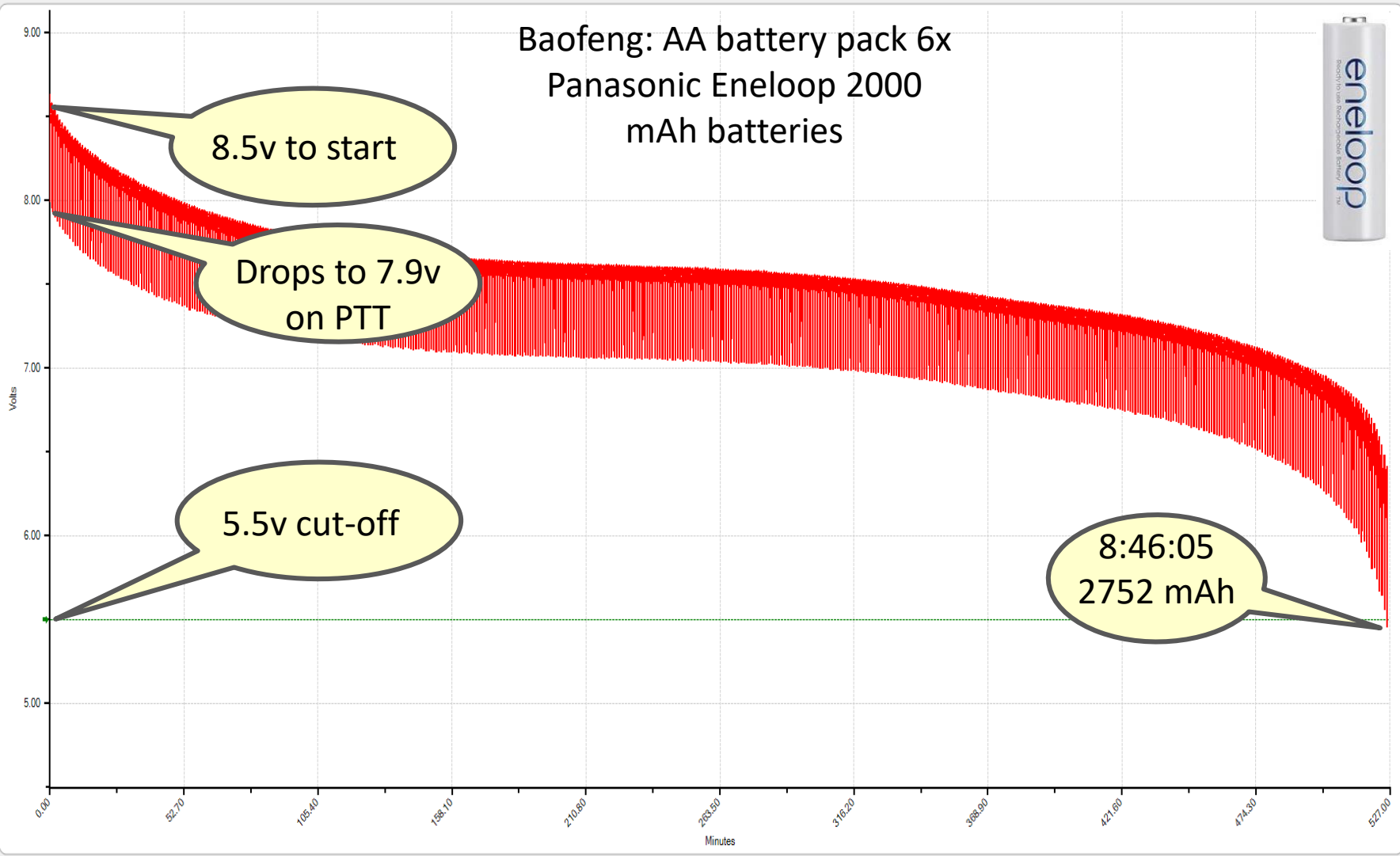
Lithiums last 15.58x longer than Alkalines

15.58 x 5 batteries = 78

# Test Results

vergizer-Ultimate-Lithium-5x-Baofer Baofeng - AA Eneloop.bt2

Baofeng - 6x Eneloop: 6 NiMH cells Multiple Discharge Profile



Voltage  
7.16

Current  
.

Amp Hr  
1762

Watts  
.

Status  
Done

Resistance  
2.12

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# Test Results

53 alkaline batteries / \$37.10 / 49.82 oz (3.11 lbs)



\$12.00 / 2.7 oz

Alkaline: 0:50 to 6v

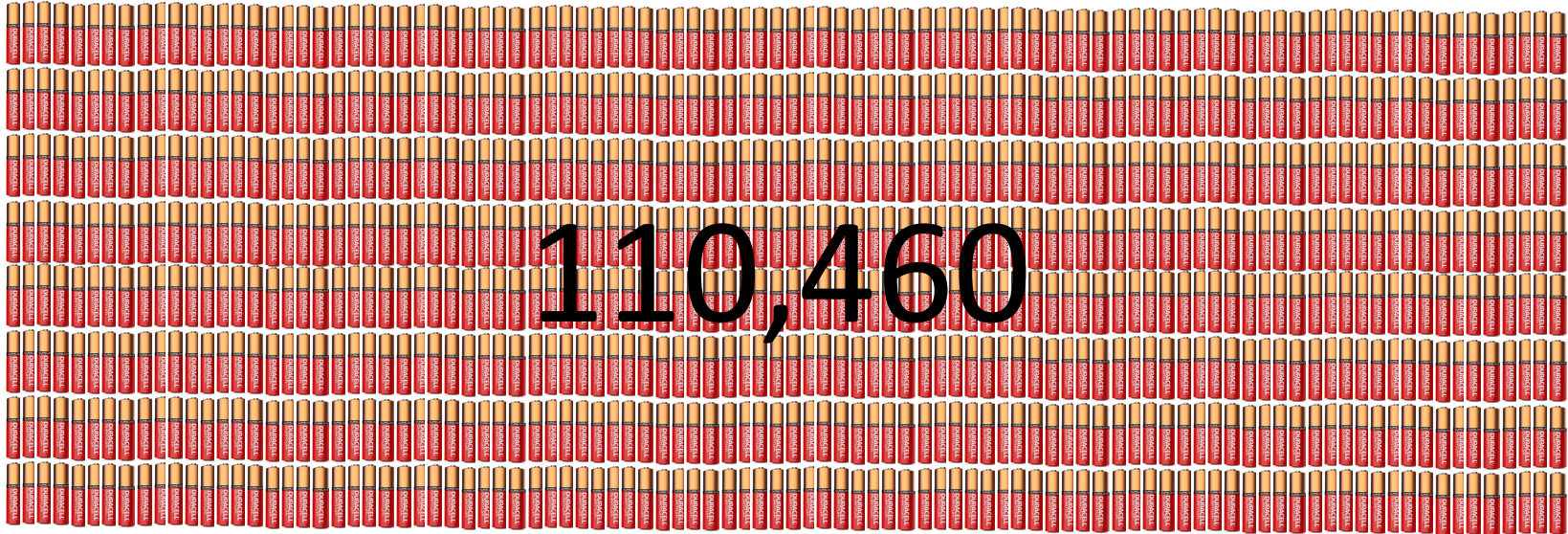
NiMH: 8:46 to 6v

NiMHs last 10.52x longer than Alkalines

10.52 x 5 batteries = 52.6

# Test Results

\$77,322 / 3.25 tons



==



\$12.00 / 2.7 oz

(plus \$50.40 to recharge then 2100 times)

- It takes 20Wh or 0.02 kWh to charge one Eneloop
- All six would take 0.12 kWh
- We pay an average of \$0.20 per kWh
- Charging all six batteries costs less than 2 ½ ¢
- To recharge them 2100 times would cost \$50.40



# Conclusion

- **Use the highest capacity Li-Ion battery available for your radio**
- **When using the AA adapter**
  - Alkaline batteries are the worst choice. Use as the last resort
  - Energizer Ultimate Lithium batteries are the best choice for single-use batteries
    - Extremely low self-discharge (95% of capacity after 20 years)
    - Handles high current discharge
    - About \$1.50 per battery
  - Panasonic Eneloop batteries are the best choice for rechargeable batteries
    - Relatively low self-discharge (85% of charge after 1 year)
    - Can be recharged up to 2100 times
    - Handles high current discharge
    - About \$2.00 per battery
    - ***Never charge from the radio***

# Small Battery Chargers

- **Maha PowerEx MH-C808M**
  - Can charge any combination of 8 AAA, AA, C, D (MaHa MH-C801D or MH-C800S if you only want to charge AA and AAA)
  - Fast and slow charge mode
  - Requires 120vac
- **NiteCore D4**
  - Can charge any combination of 4 AA, AAA, AAAA, C, 26650, 22650, **18650**, 17670, 18490, 17500, 18350, 16340, 14500, 10440
  - Can charge from either 120vac or 12vdc (adapter included)
- **Xtar Dragon VP4**
  - Can charge any combination of 4 AAAA, AAA, AA, A, SC, C, D, 10440, 14500, 14650, 16340, 17335, 17500, 17670, 18350, 18490, 18500, **18650**, 22650, 2550, 26650, 32650
  - 0.5a to 2.0a charging modes
  - Can charge from either 120vac or 12vdc (adapter included)



# 12v Batteries

- **Why 12v batteries**
  - Mobile radios
  - Recharge HT radios, mobile phones, tablets, laptops, rechargeable batteries, lighting, television, etc
  - Easy to charge from solar or from your car
- **Lots of different size batteries available from small 7Ah sealed lead acid (SLA) to large 100+Ah absorbed glass mat (AGM)**
- **Different chemistries available include lead acid, lithium iron phosphate (LiFePO<sub>4</sub>), Lithium-Ion...you can even make a 12v battery from alkaline or NiMH batteries**
- **Amp Hour Measurement is typically at 20 hours**
  - Peukert Effect
  - As the discharge amps increase, the batteries available capacity decreases

# Batteries

## ➤ Capacity (Amp Hour Rating)

- How many amps can be delivered over a period of time before the battery is completely dead

CAPACITY <sup>B</sup> Amp-Hours (AH) Trojan Group 27 - 100 AH AGM Battery				ENERGY (kWh)
5-Hr Rate 15.4 amps	10-Hr Rate 8.2 amps	20-Hr Rate 4.45 amps	100-Hr Rate 1 amp	100-Hr Rate
<b>12 VOLT DEEP CYCLE AGM BATTERY</b>				
77	82	89	99	1.19

# Lead Acid

- Flooded (Automobile starter, Maintenance free, Deep cycle, Golf cart batteries)

- Peukert constant = 1.6



- Sealed Lead Acid

- Gel

- Peukert constant = 1.25



- Absorbed Glass Matte (AGM)

- Peukert constant = 1.15



# Lead Acid

- **Pros**

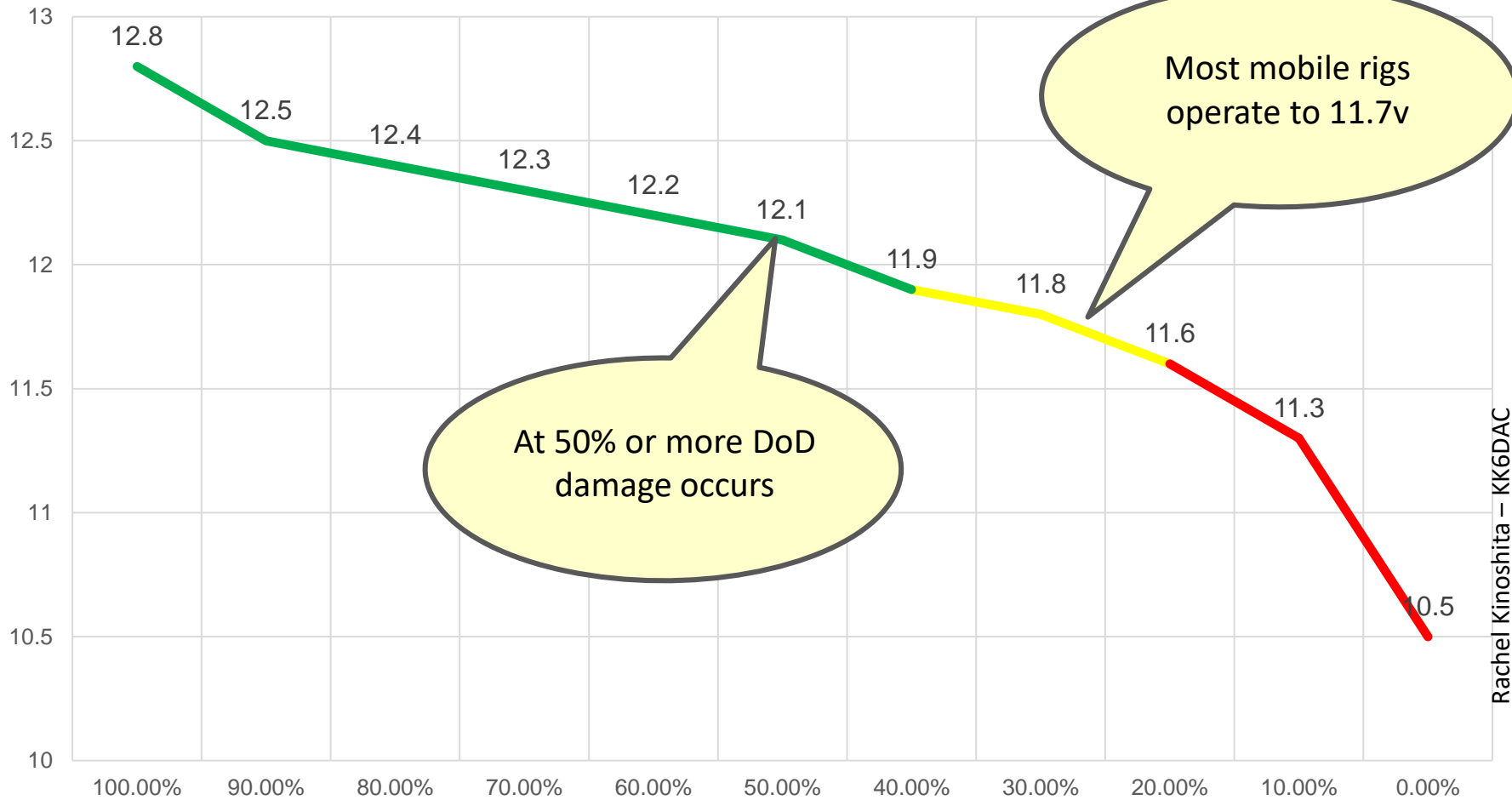
- Flooded (Automobile starter, Maintenance free, Deep cycle, Golf cart batteries)
  - Proven technology
  - Relatively inexpensive
- Sealed/Gel
  - No outgassing
  - Can be installed in any position
- Absorbed Glass Matte (AGM)
  - No outgassing
  - Can be installed in any position
  - Relatively long life (5+ years)

- **Cons**

- Flooded
  - Heavy
  - Outgas
  - Spill hazard
- Sealed/Gel
  - Heavy
- AGM
  - Heavy
  - Expensive

# Lead Acid

## 12v Lead Acid Voltage Curve



# Lithium Iron Phosphate (LiFePO<sub>4</sub>)

- **Pros**

- Very low self-discharge
- Relatively flat discharge curve
- Can be recharged thousands of times
- At 3.2vdc per cell, 4 cells in series (4s) has a nominal voltage of 12.8v and max voltage of 14.2v
- Will not leak
- No outgassing
- High energy density
- Can be charged with a power supply or charger set to 14.2v to 15.1v\*
- Unlike Li-Ion, LiFePO<sub>4</sub> is very safe
- Peukert constant = 1.01 or less

- **Cons**

- Expensive

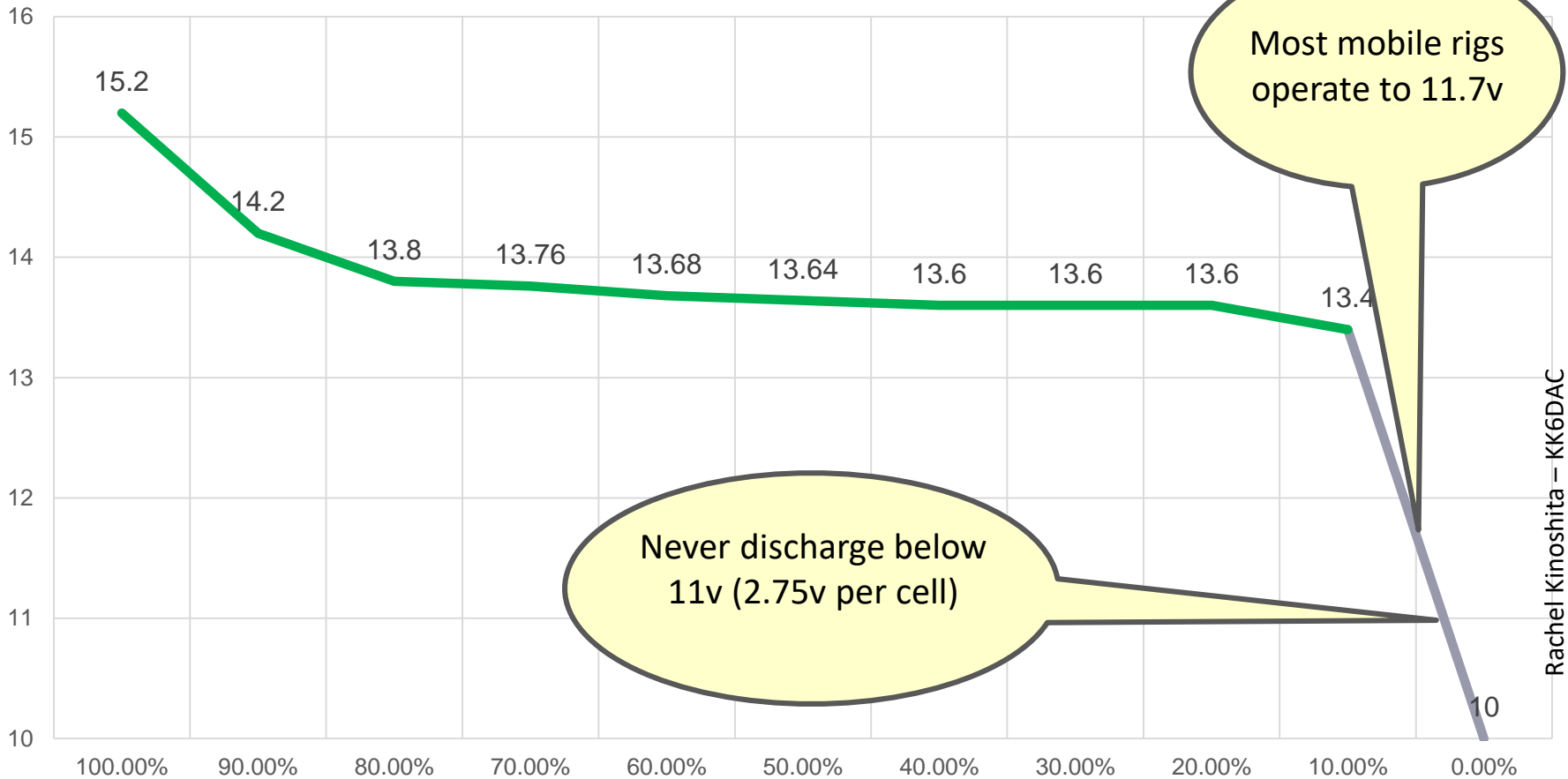


\*With a Bioenno BMS. May also work with other LiFePO<sub>4</sub> battery BMS



# Lithium Iron Phosphate (LiFePO<sub>4</sub>)

LiFePO<sub>4</sub> Voltage Curve





# Test methodology

- **Used the Multi-Discharge test using the following settings**
  - Low-Voltage cut-off: 11.2v
  - 1s steps until cut-off voltage is met
  - Three step discharge (simulate 50w transmit)
    - 15s @ 10.3a (transmit)
    - 30s @ 1a (receive)
    - 15s @ 0.1a (idle)
  - Three step discharge (simulate 25w transmit)
    - 15s @ 6.5a (transmit)
    - 30s @ 1a (receive)
    - 15s @ 0.1a (idle)
- **Batteries were fully charged before testing**
- **Sealed Lead Acid battery used was an ExpertPower EXP 12200 12v, 20 Ah purchased on Amazon for \$38.00; 12.5 lbs**
- **LiFePO4 battery used was a Bioenno BLF-1220W/A 12v, 20 Ah purchased at Ham Radio Outlet \$192.95; 5.5 lbs**

# Test Results

12v SLA - High Power.bt2

12v SLA - High Power: 6 Lead Acid cells Multiple Discharge Profile

## Sealed Lead Acid 12v 20 AH battery (50w simulation)

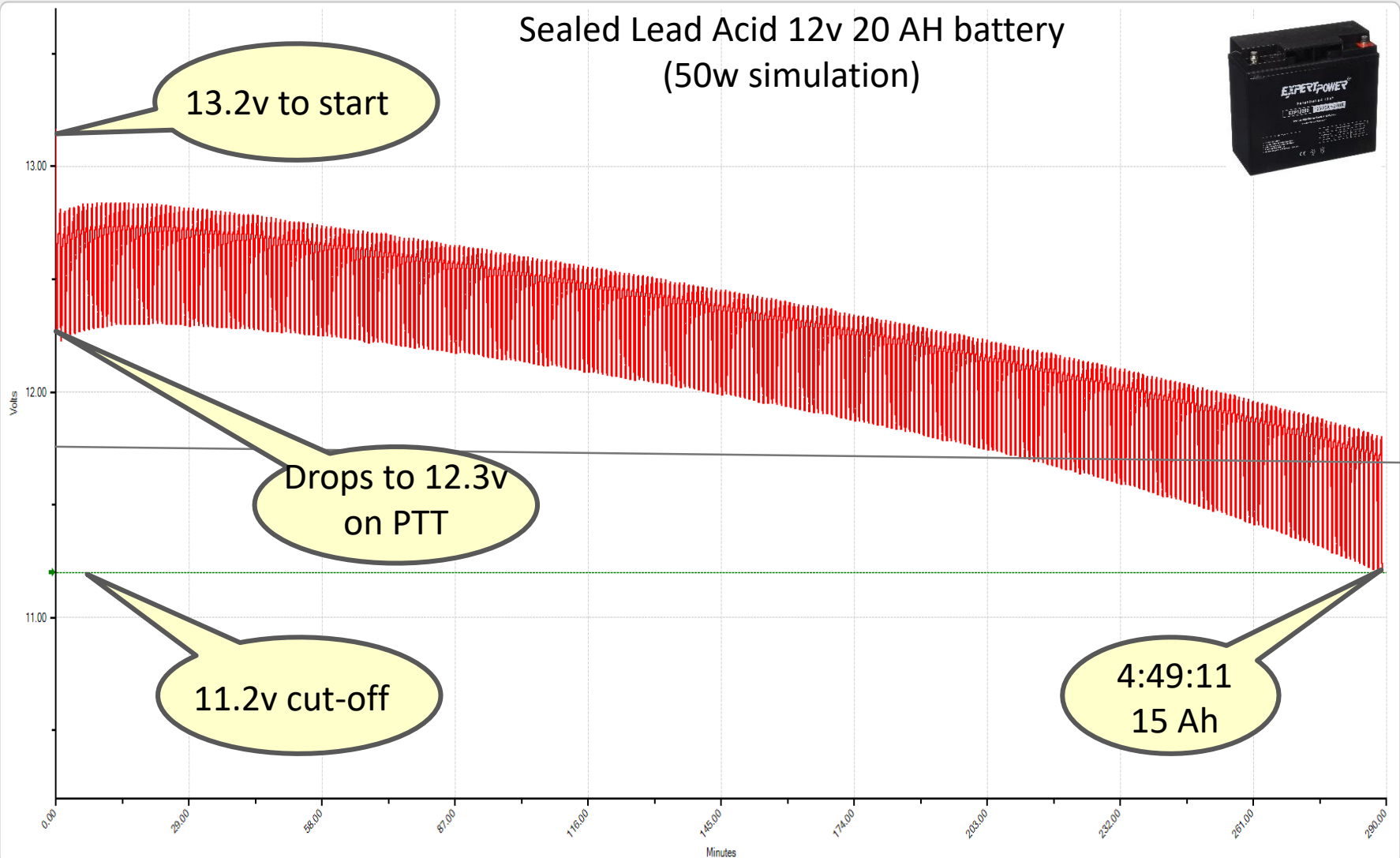


13.2v to start

Drops to 12.3v  
on PTT

11.2v cut-off

4:49:11  
15 Ah



Voltage  
12.09

Current  
-

AmpHr  
15.024

Watts  
-

Status  
Done

Resistance  
0.19

Rachel Kinoshita - KK6DAC

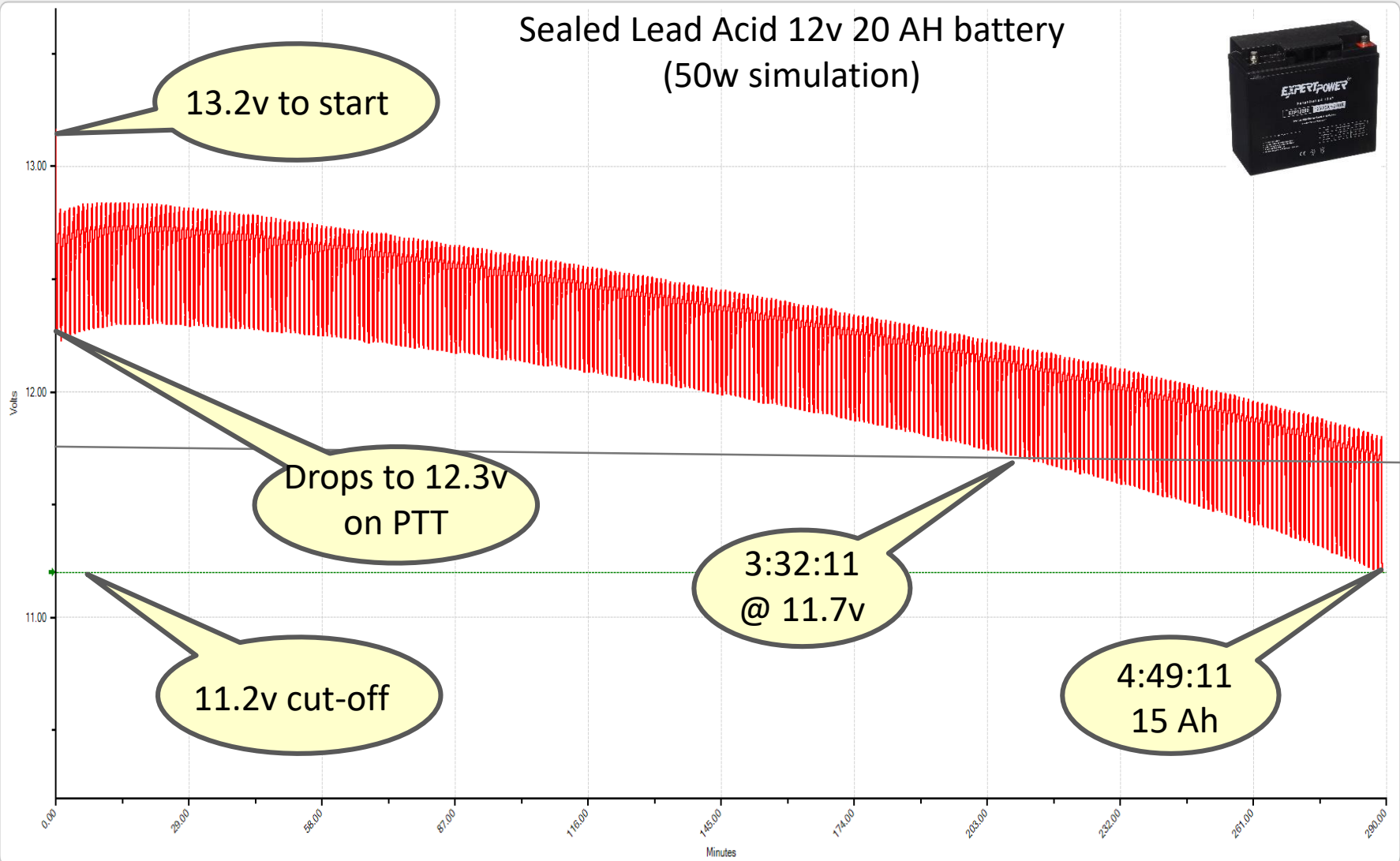
60

# Test Results

12v SLA - High Power.bt2

12v SLA - High Power: 6 Lead Acid cells Multiple Discharge Profile

## Sealed Lead Acid 12v 20 AH battery (50w simulation)



Voltage  
12.09  
Current  
AmpHr  
15.024  
Watts  
Status  
Done  
Resistance  
0.19

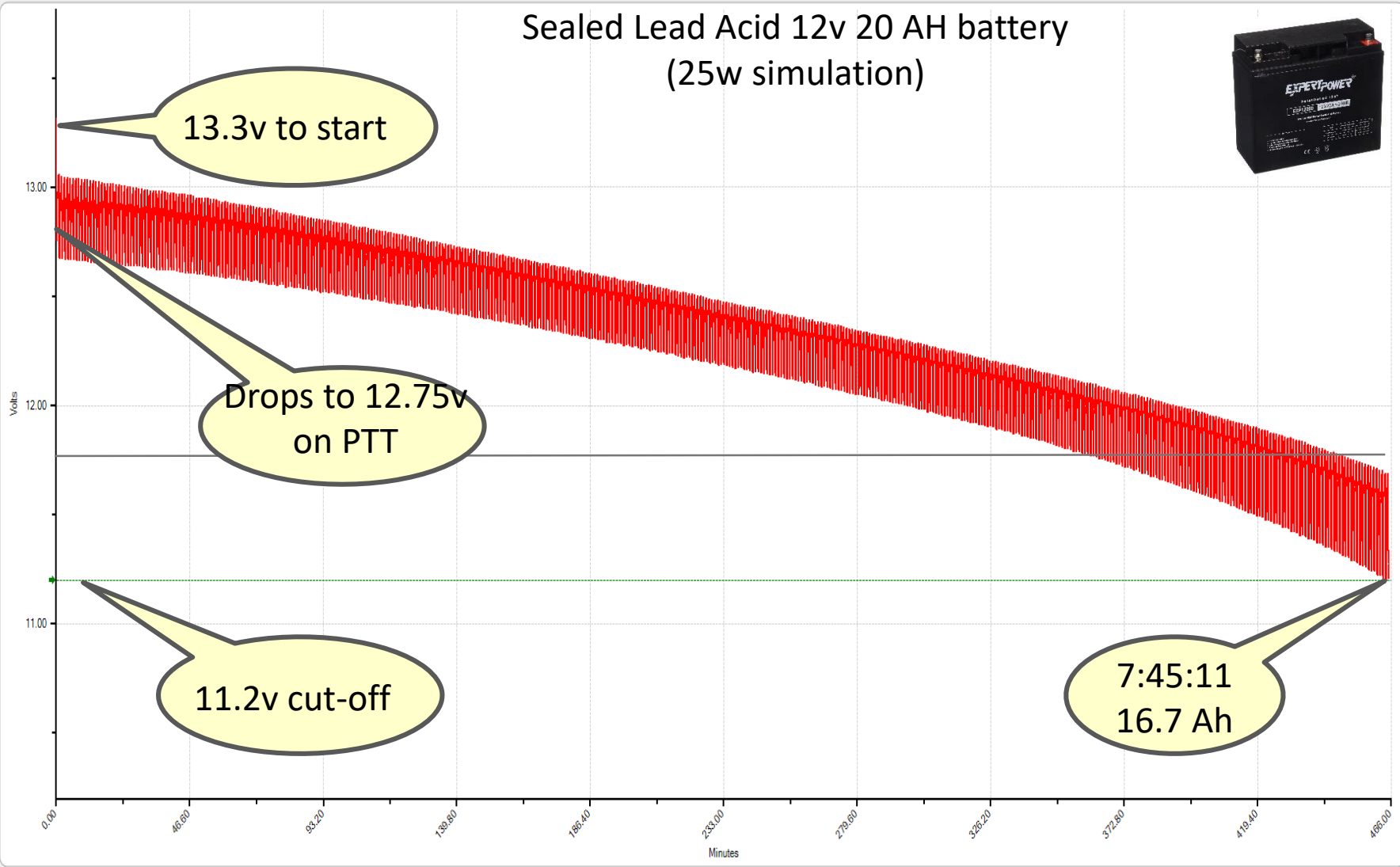
Rachel Kinoshita - KK6DAC

# Test Results

12v SLA - Med Power.bt2

12v SLA - Med Power: 6 Lead Acid cells Multiple Discharge Profile

## Sealed Lead Acid 12v 20 AH battery (25w simulation)



Voltage  
  
Current  
  
AmpHr  
  
Watts  
  
Status  
  
Resistance

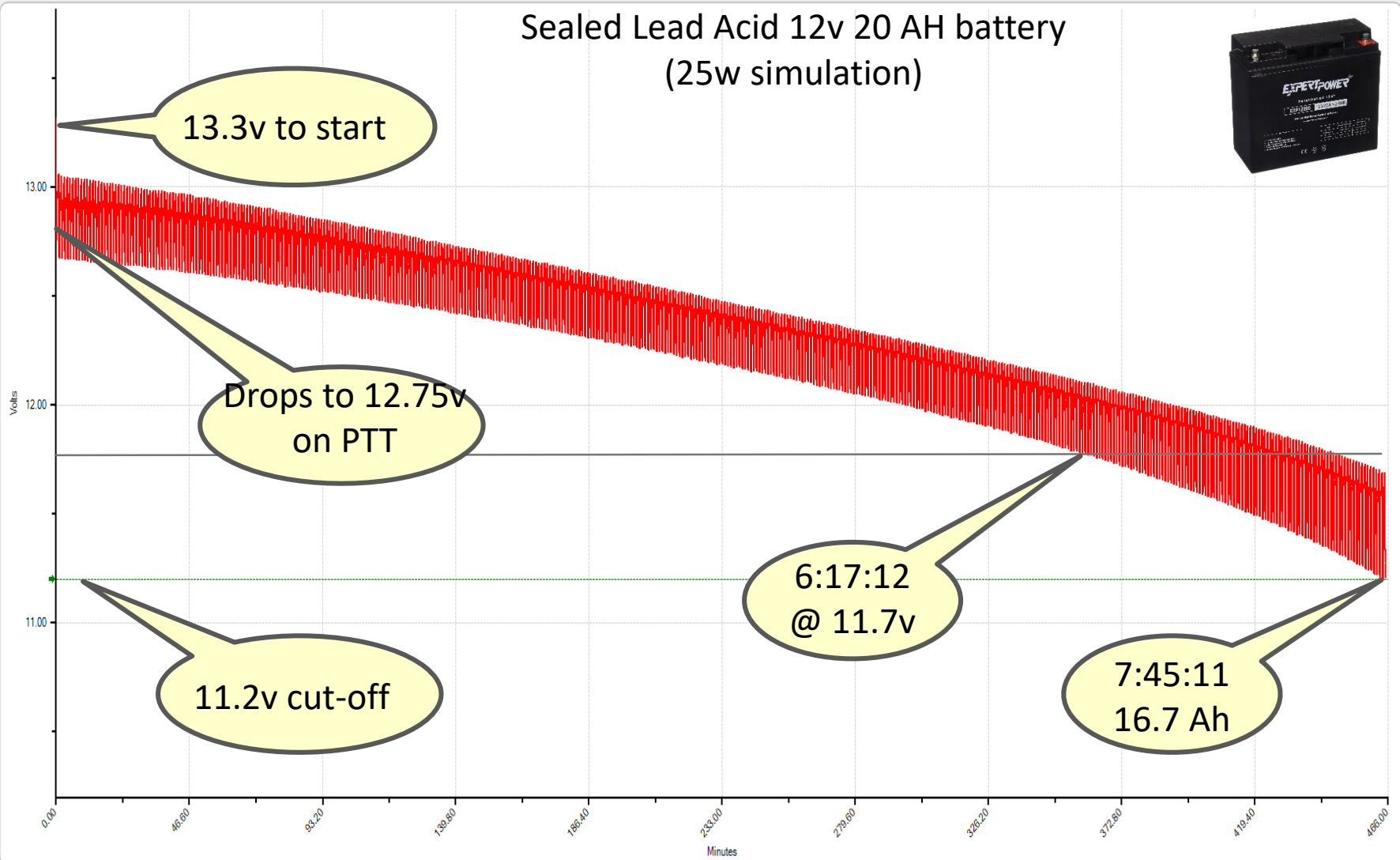
Rachel Kinoshita - KK6DAC

# Test Results

12v SLA - Med Power.bt2

12v SLA - Med Power: 6 Lead Acid cells Multiple Discharge Profile

### Sealed Lead Acid 12v 20 AH battery (25w simulation)



Voltage  
0.00  
Current  
.  
AmpHr  
16.731  
Watts  
.  
Status  
Done  
Resistance  
0.33

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# Test Results

12v LiFePO4 - High Power.bt2

— 12v LiFePO4 - High Power: 4 LiFePO4 cells Multiple Discharge Profile

LiFePO4 12v 20 AH battery (50w simulation)

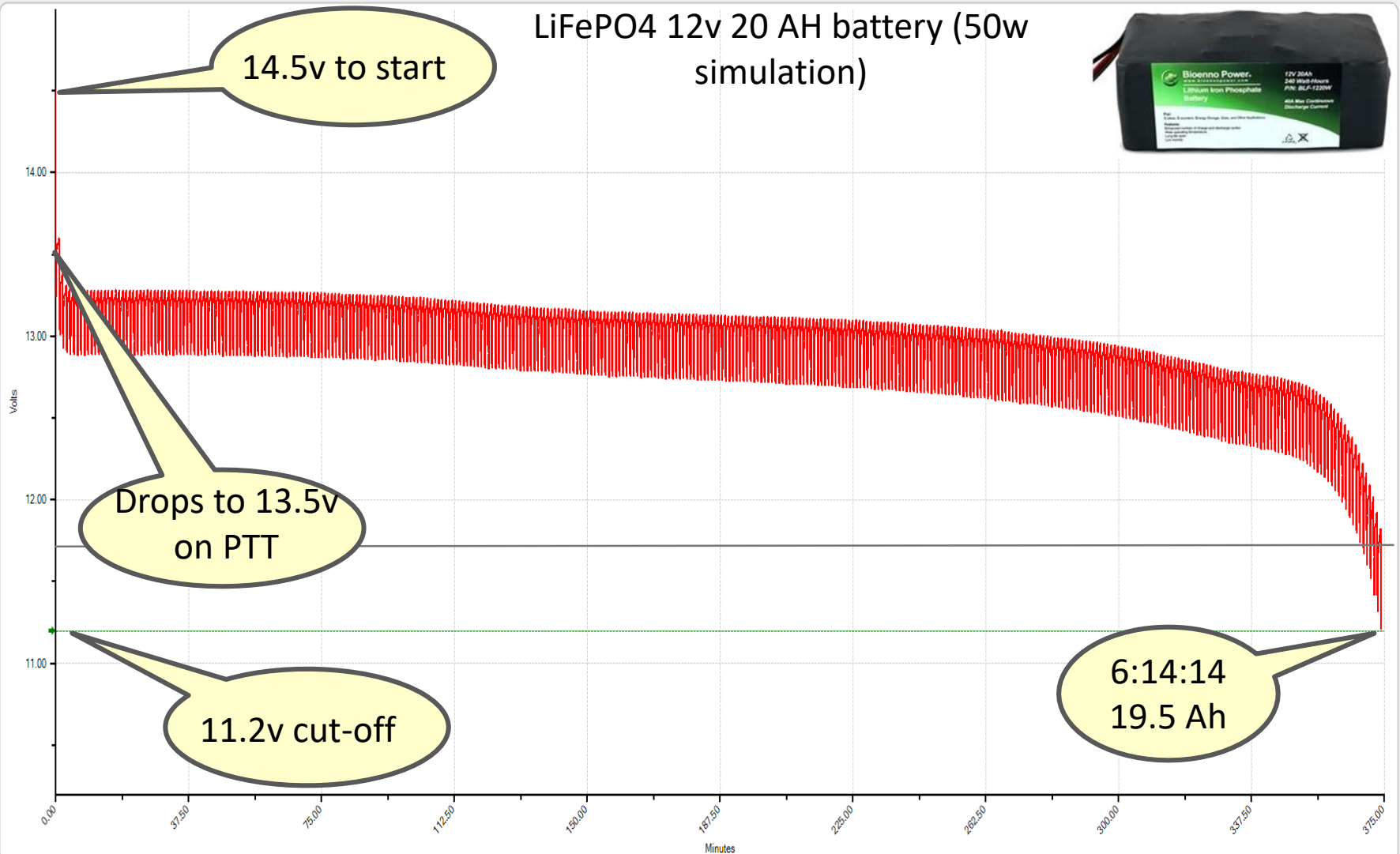


14.5v to start

Drops to 13.5v on PTT

11.2v cut-off

6:14:14  
19.5 Ah



Voltage

12.18

Current

-

AmpHr

19.487

Watts

-

Status

Done

Resistance

0.32

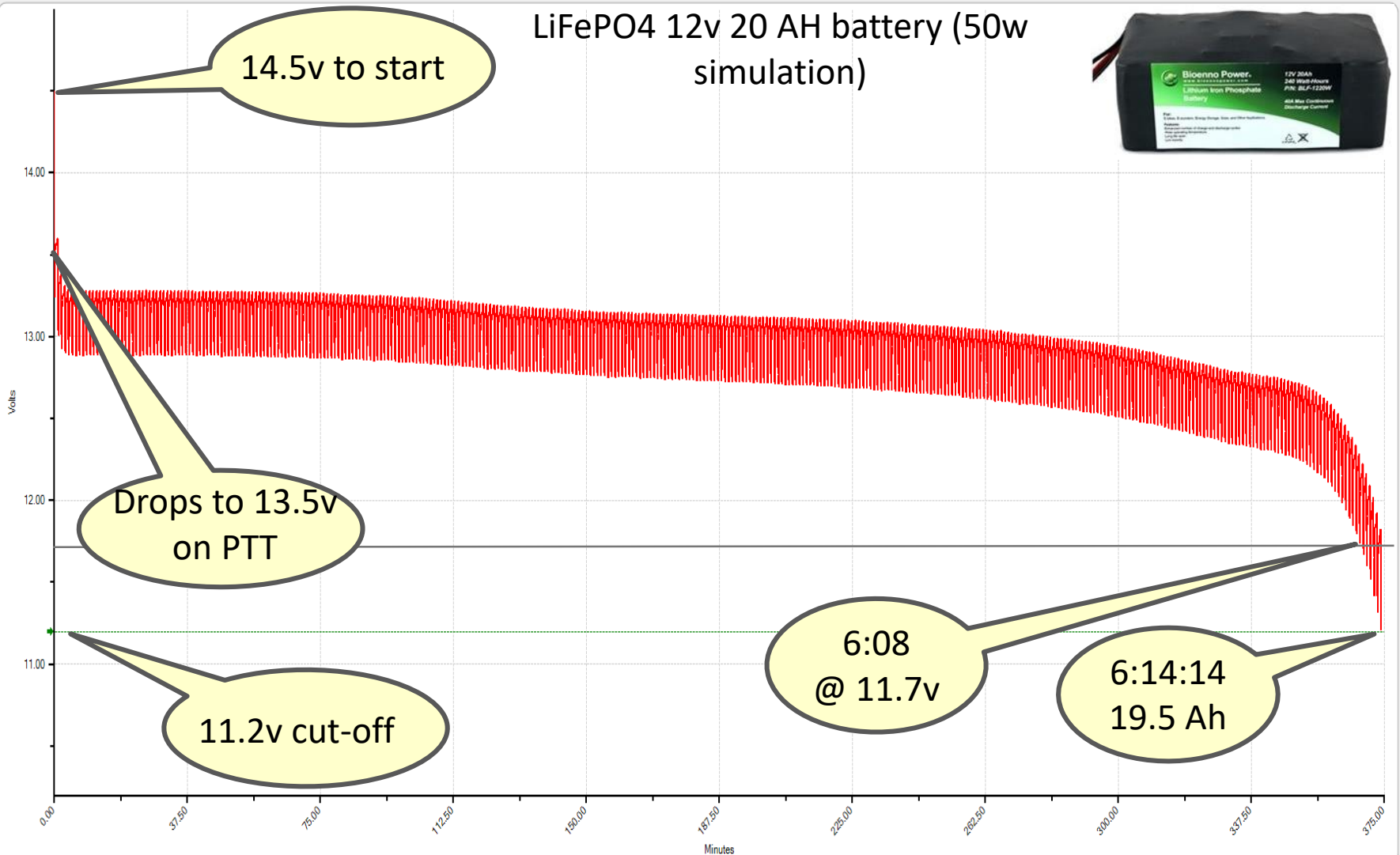


# Test Results

12v LiFePO4 - High Power.bt2

— 12v LiFePO4 - High Power: 4 LiFePO4 cells Multiple Discharge Profile

LiFePO4 12v 20 AH battery (50w simulation)



Voltage

12.18

Current

-

AmpHr

19.487

Watts

-

Status

Done

Resistance

0.32

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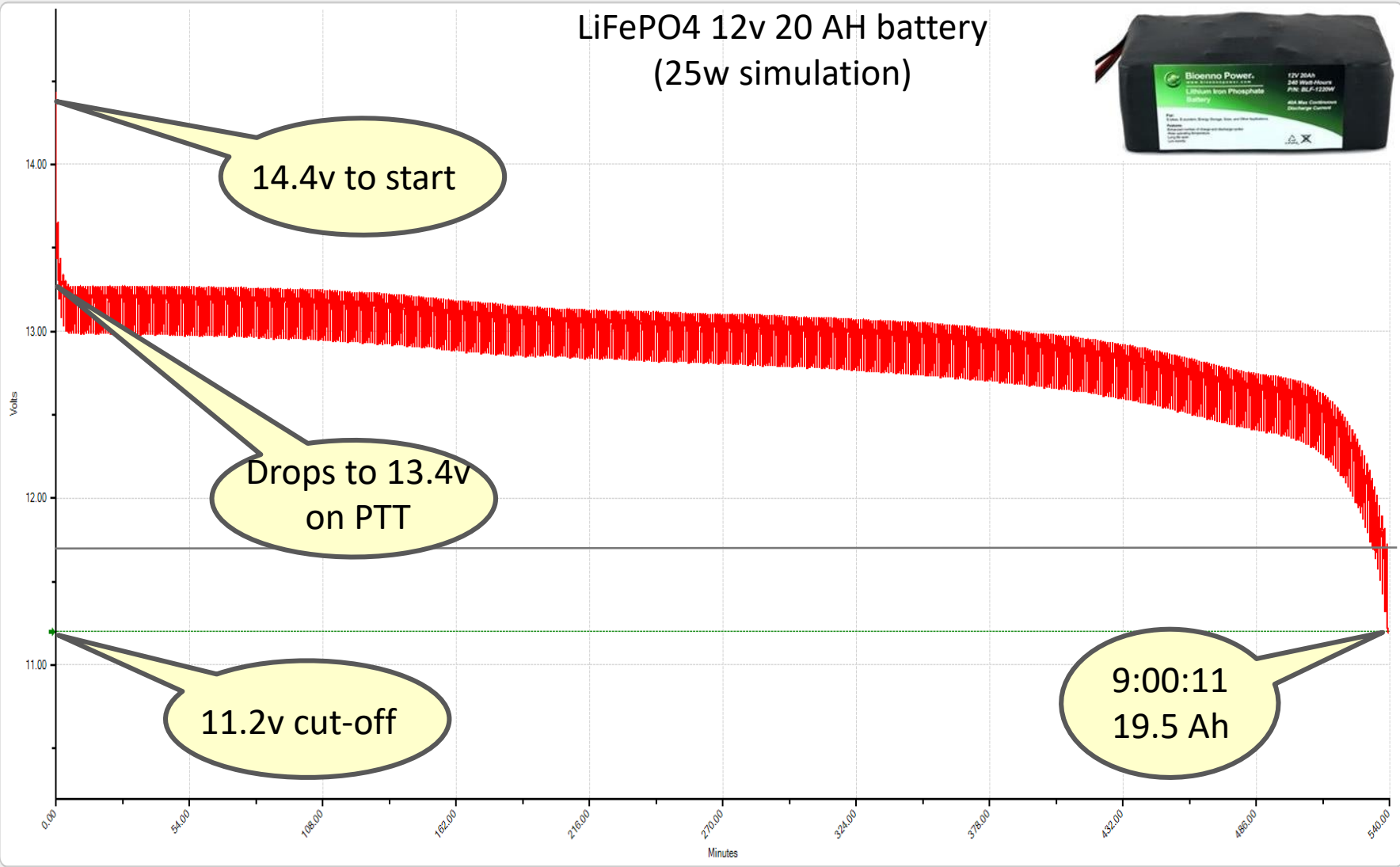
65

# Test Results

12v LiFePO4 - Med Power02.bt2

— 12v LiFePO4 - Med Power: 4 LiFePO4 cells Multiple Discharge Profile

## LiFePO4 12v 20 AH battery (25w simulation)



Voltage  
12.12  
Current  
.  
AmpHr  
19.421  
Watts  
.  
Status  
Done  
Resistance  
0.50

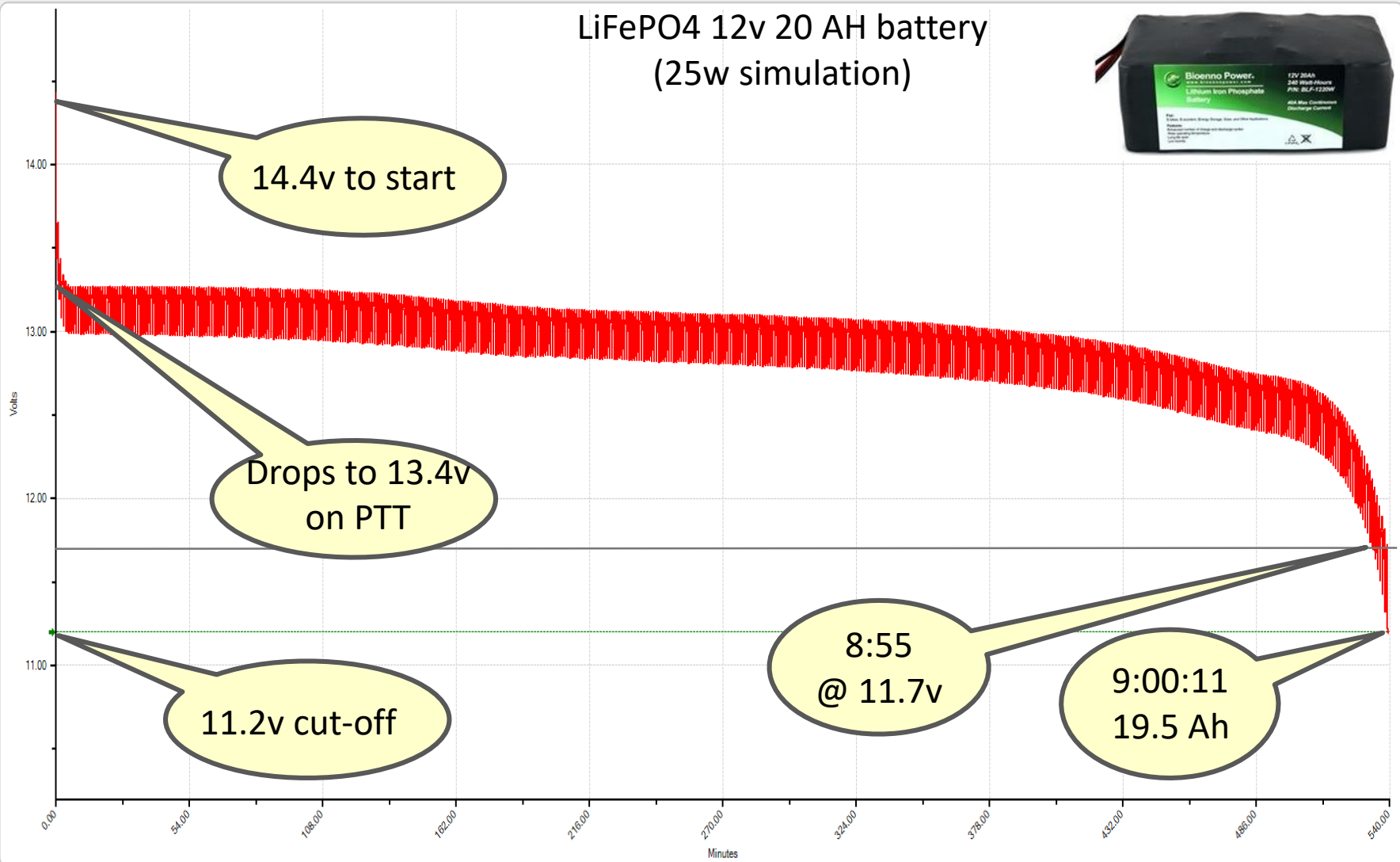
Rachel Kinoshita - KK6DAC

# Test Results

12v LiFePO4 - Med Power02.bt2

— 12v LiFePO4 - Med Power: 4 LiFePO4 cells Multiple Discharge Profile

## LiFePO4 12v 20 AH battery (25w simulation)



Voltage  
12.12

Current  
-

AmpHr  
19.421

Watts  
-

Status  
Done

Resistance  
0.50

Rachel Kinoshita - KK6DAC

# Test Results

\$53.00 / 17.5 lbs



3:32	4:49	6:17	7:45	Pb
6:08	6:14	8:55	9:00	LiFePo4
1.74	1.29	1.42	1.16	1.40

=



\$192.95 / 5.5 lbs

# Test Results

\$213.00 / 70.1 lbs



Can be fully recharged up to 500 times

=



Can be fully recharged up to 2000 times

\$192.95 / 5.5 lbs

# Using Batteries in Emergency Communications

- **Post Katrina, FEMA was left with more trailers than they knew what to do with**





# Using Batteries in Emergency Communications

- The problem was exacerbated because many of the trailers had toxic levels of formaldehyde



# Using Batteries in Emergency Communications

- In late 2014 / early 2015 the Menlo Fire District acquired a surplus FEMA Katrina trailer





# Using Batteries in Emergency Communications

- **Menlo Fire purchased the CERT trailer to provide a platform for communications during an emergency or disaster**
- **The trailer was outfitted with amateur radios, computers, monitors, a generator, antennas and other accessories necessary to operate**
- **In that configuration it required manual charging of the battery on a regular basis to prevent battery damage due to low voltage**
- **Generators require fuel, regular oil changes and have moving parts which can fail**
- **In a disaster, gasoline for the generator may become a scare resource**
- **Configuring the trailer to run stand-alone with only batteries and PV panels would ensure independent operations during a disaster**

# Menlo Park CERT Communications Trailer



# Menlo Park CERT Communications Trailer



# Menlo Park CERT Communications Trailer

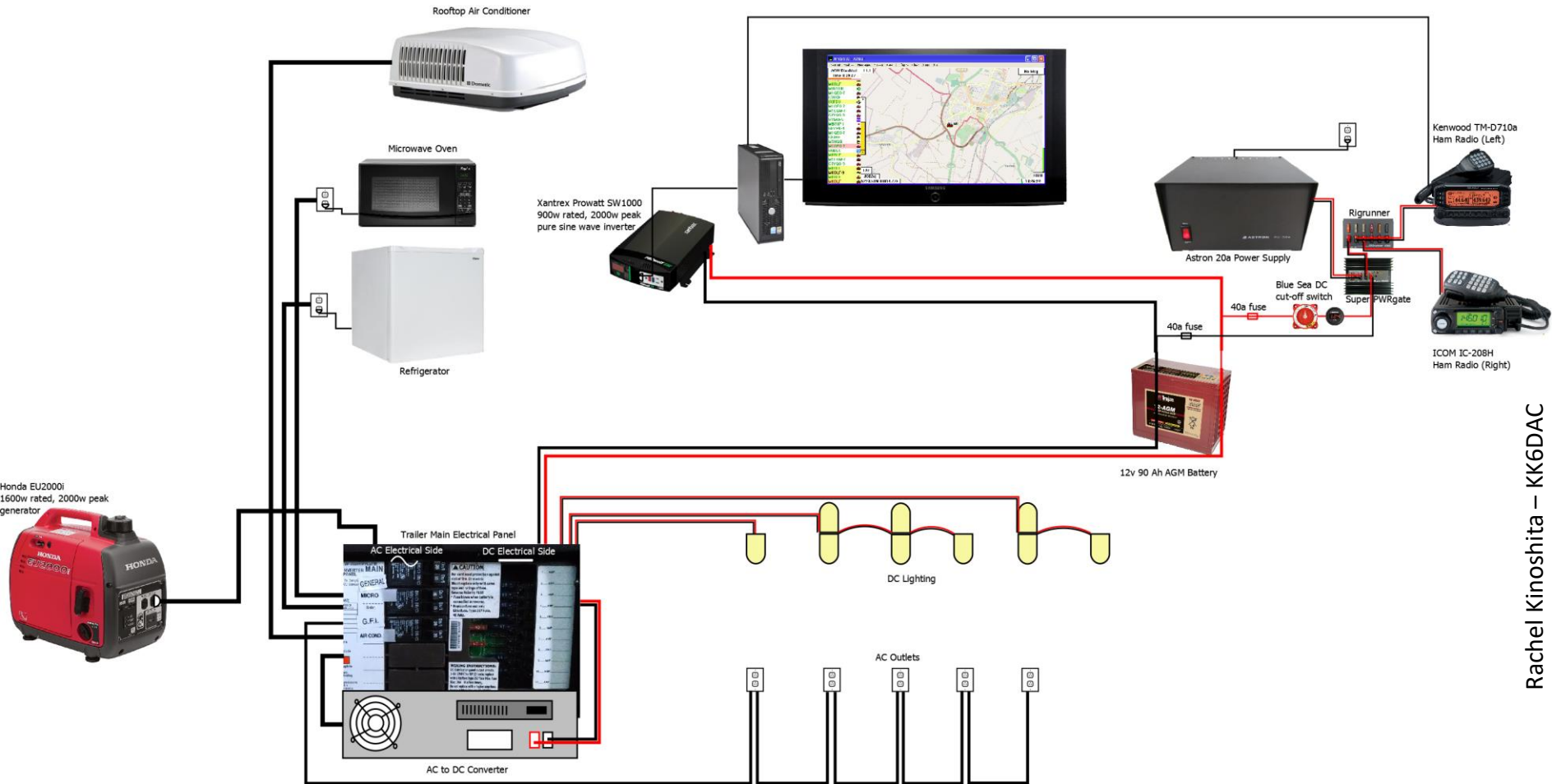




# Menlo Park CERT Communications Trailer



# Menlo Park CERT Communications Trailer



# Menlo Park - Proposed System

- **Batteries will automatically be maintained**
- **Trailer will always be ready to be deployed**
- **Provides sufficient power to run radios, computers and lights for an extended period of time**
- **Reduces or removes dependency on gasoline or propane generator**
- **Designed for growth**

# Menlo Park - Proposed System

60A MPPT Solar Charge Controller



6 slot Solar Combiner box



4x 250w PV Panels

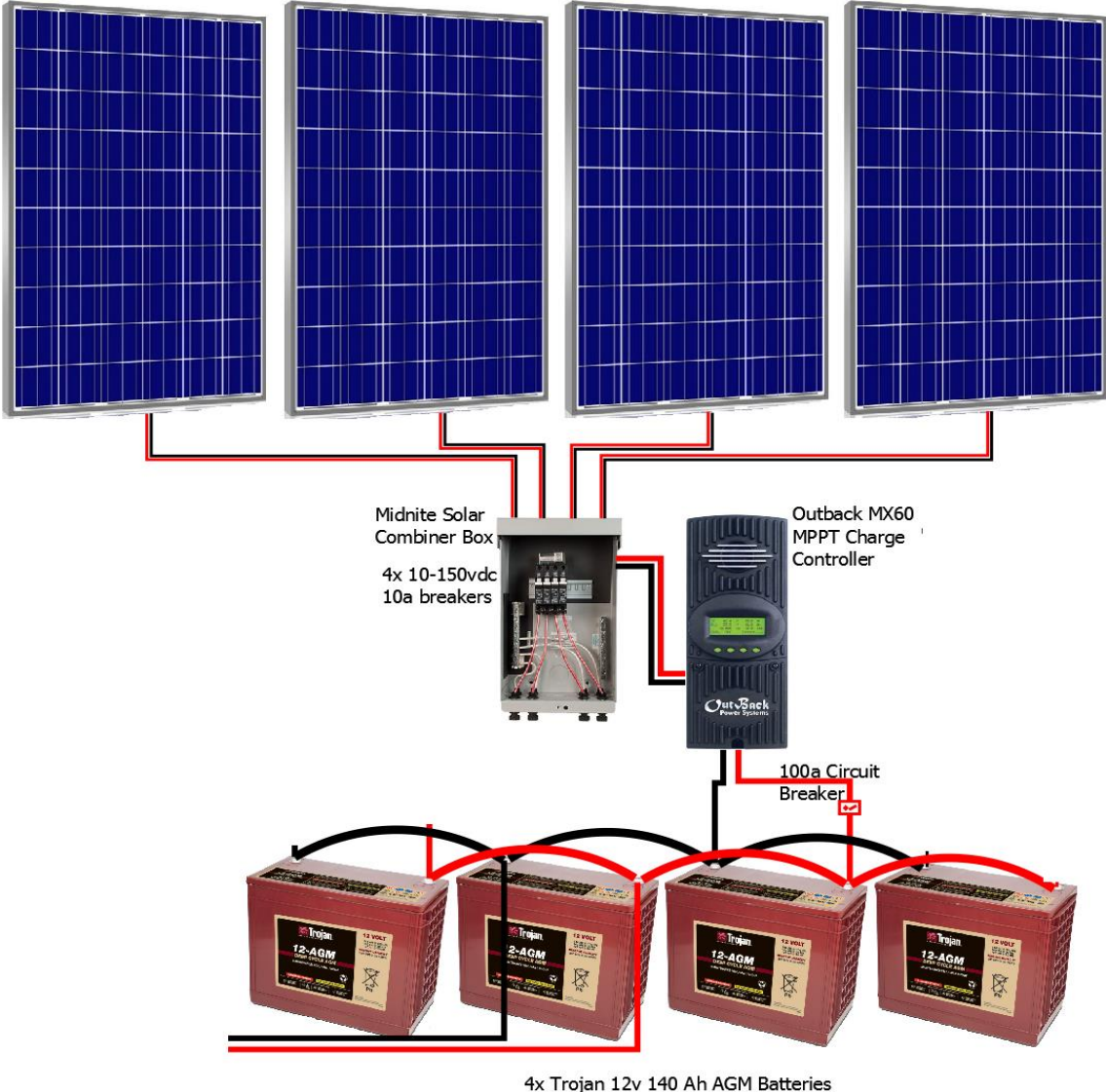
4x 140Ah AGM Batteries



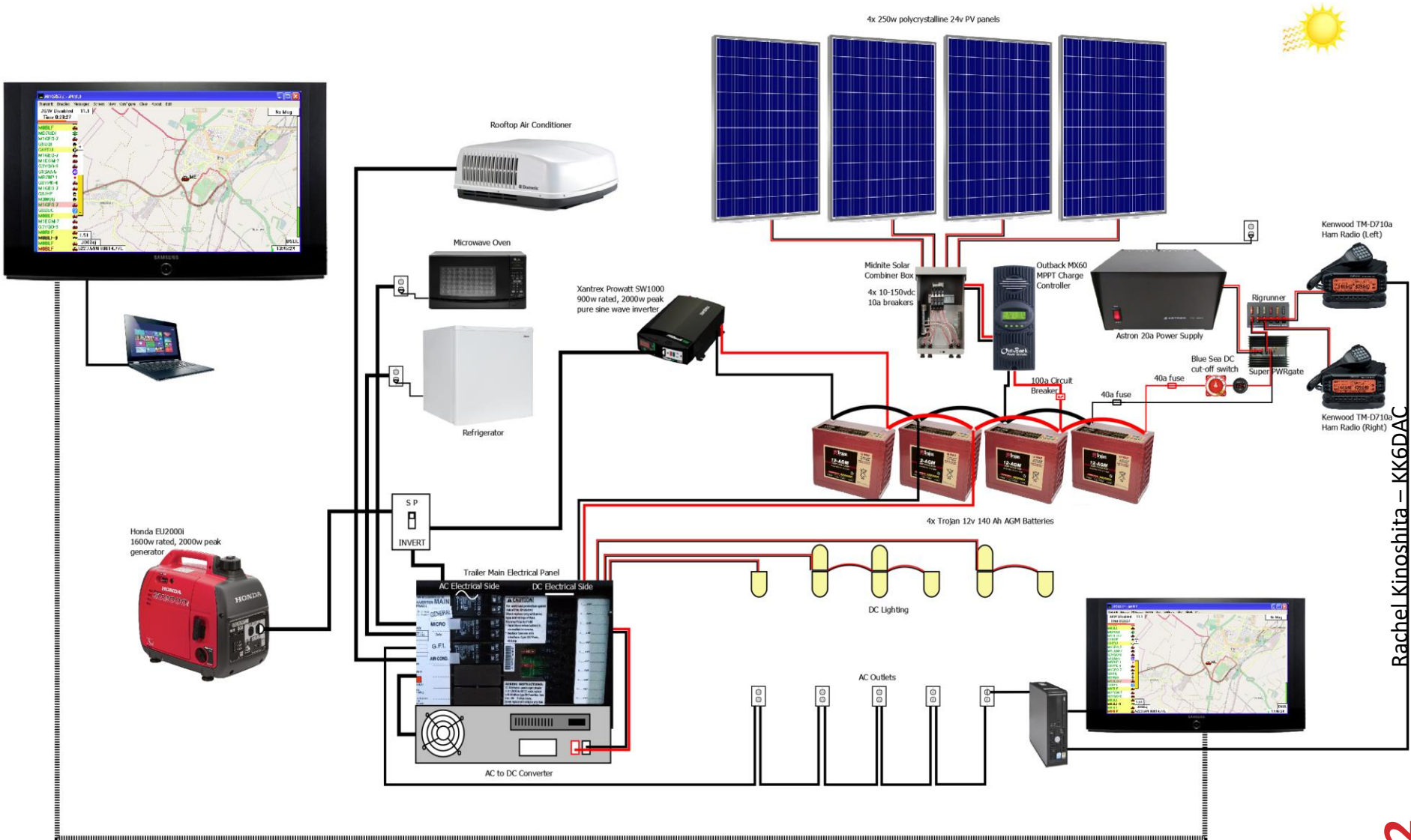


# Menlo Park – Completed System

4x 250w polycrystalline 24v PV panels

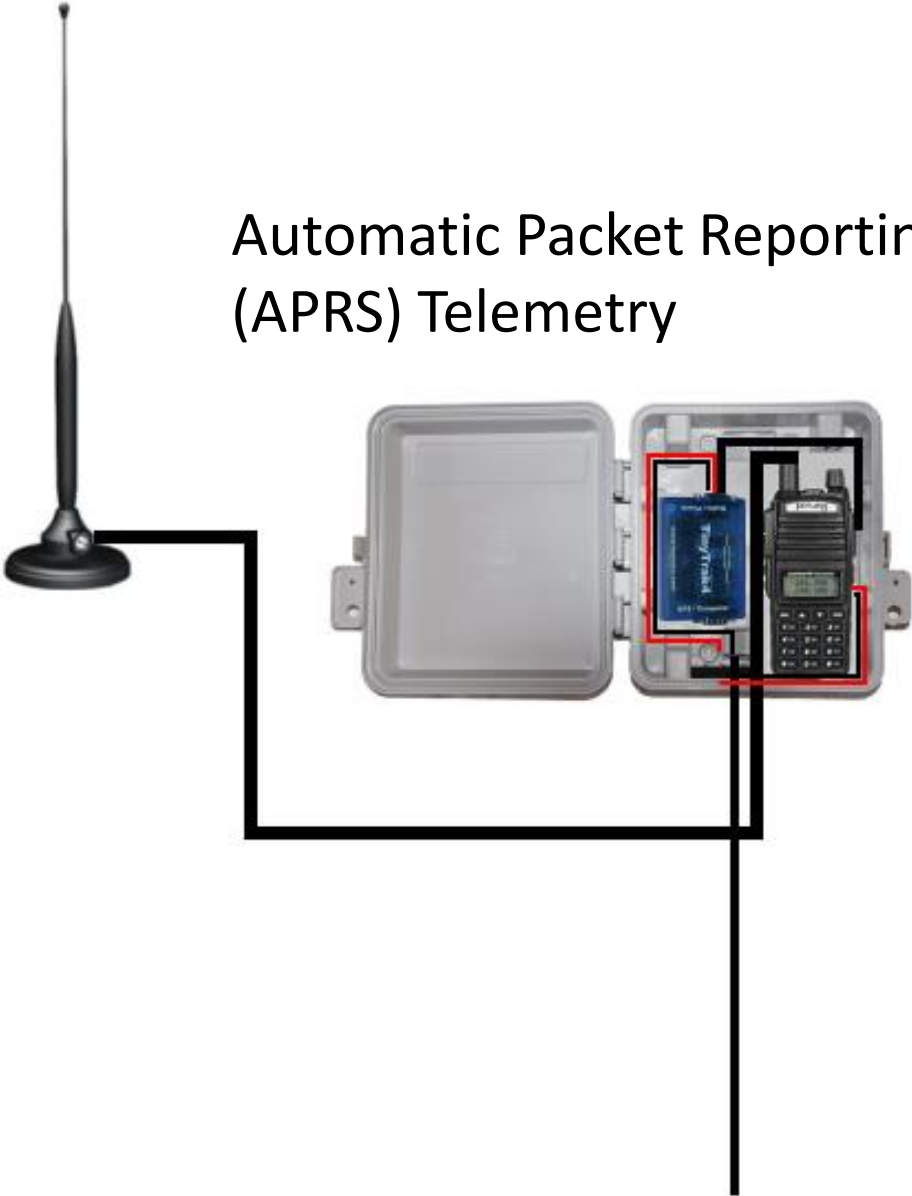


# Menlo Park CERT Communications Trailer



# Menlo Park CERT Communications Trailer

Automatic Packet Reporting System (APRS) Telemetry





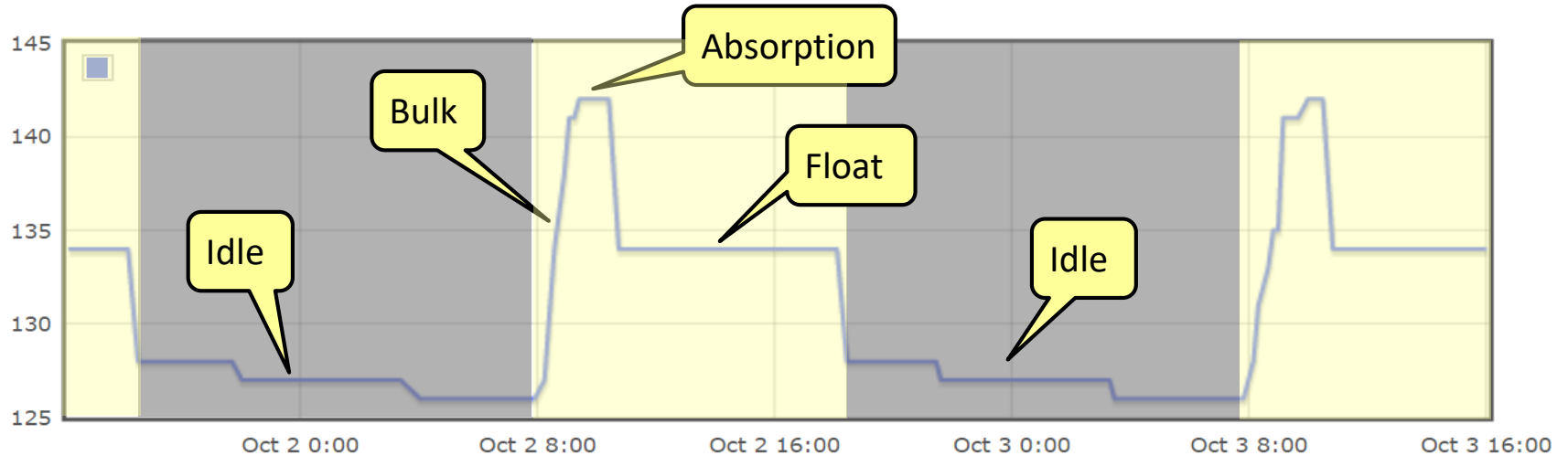
# Menlo Park CERT Communications Trailer



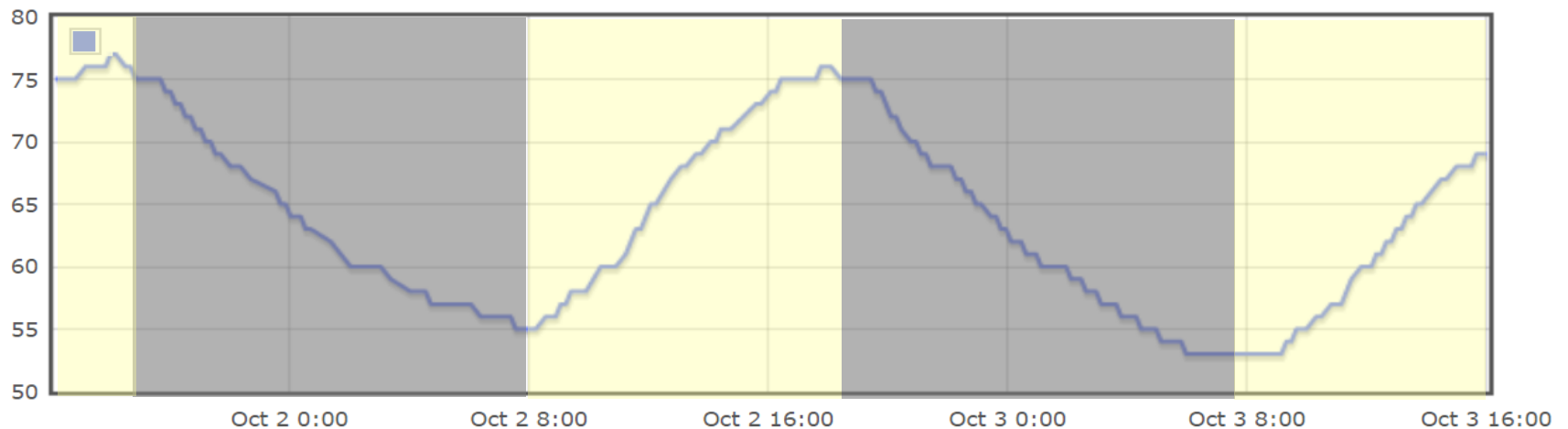


# Menlo Park – 48 Hours of Collected Data

KK6DAC-15 Channel 1 2017-10-01 16:12:57 -> 2017-10-03 16:02:29 PDT

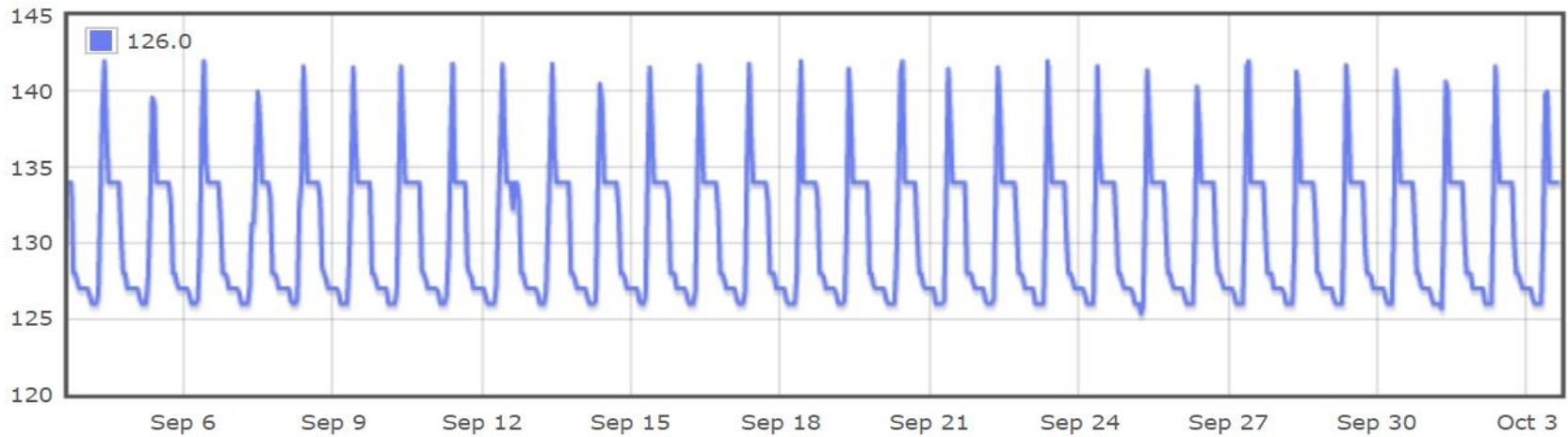


KK6DAC-15 Channel 2 2017-10-01 16:12:57 -> 2017-10-03 16:02:29 PDT

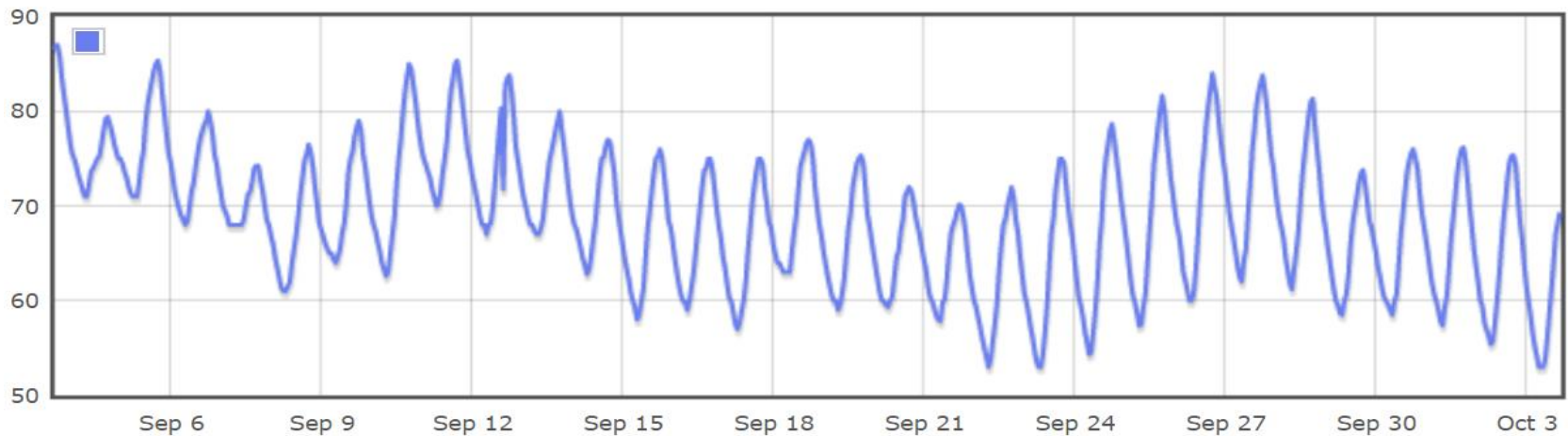


# Menlo Park – 1 Month of Collected Data

KK6DAC-15 Channel 1 2017-09-03 16:00:00 -> 2017-10-03 16:00:00 PDT



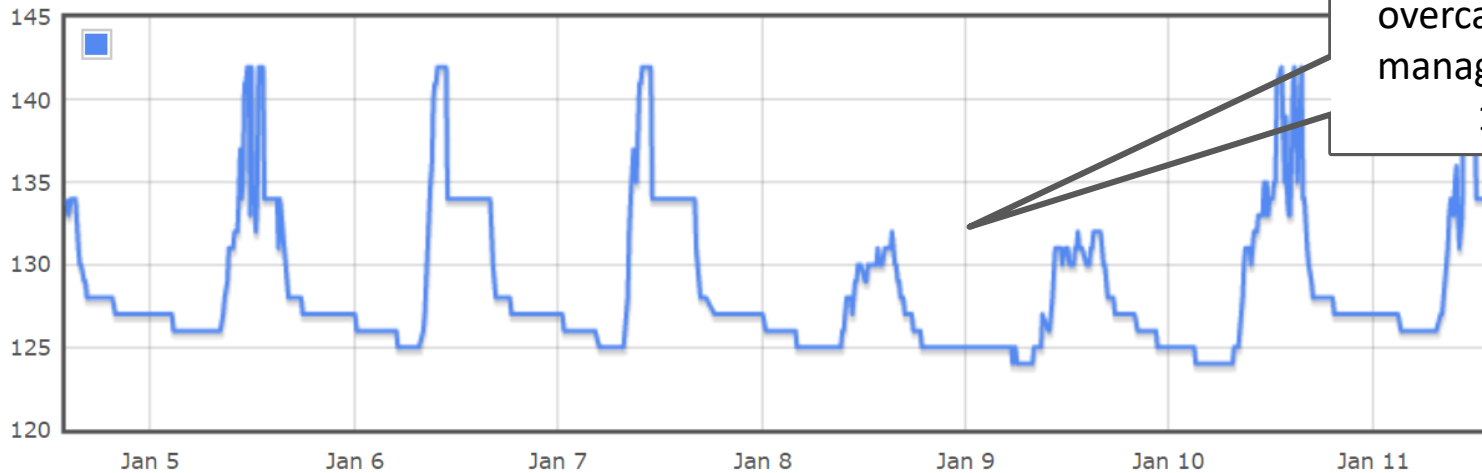
KK6DAC-15 Channel 2 2017-09-03 16:00:00 -> 2017-10-03 16:00:00 PDT



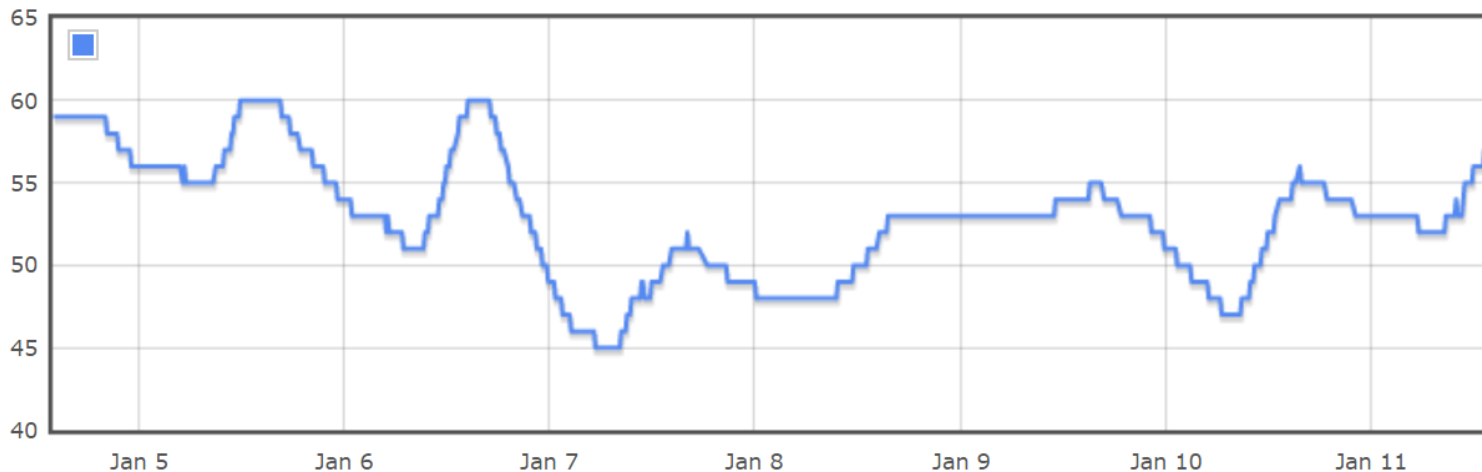


# Menlo Park – How Are We Doing this Winter?

KK6DAC-15 Channel 1 2018-01-04 14:11:44 -> 2018-01-11 14:02:47 PST



KK6DAC-15 Channel 2 2018-01-04 14:11:44 -> 2018-01-11 14:02:47 PST





# Menlo Park CERT – What Did it Cost?

Qty	Desc	Price	Total
4	Trojan 12v 140ah AGM Battery	\$420.00	\$1,680.00
4	Amerisolar 250w 24v PV panel	\$170.00	\$680.00
2	Solarline 50' cables with MC4 connectors	\$44.00	\$88.00
4	Aluminum Z bracket kit	\$9.00	\$36.00
1	Outback FX60 12-48v MPPT Charge Controller	\$602.00	\$602.00
1	Midnite Solar MNPV6 Combiner Box	\$95.00	\$95.00
4	Midnite 150VDC MNEPV DIN Mount Breaker	\$16.00	\$64.00
1	Misc wire and connectors	\$200.00	\$200.00
1	Lab bolts and sealant	\$40.00	\$40.00
1	Shipping	\$400.00	\$400.00
	<b>Total</b>		<b>\$3,885.00</b>

# Conclusion

- **Portable Operations**

- Lead acid batteries are relatively inexpensive, but the trade-off is weight, capacity, self-discharge and overall life; Only sealed lead acid batteries should be used to prevent spillage
- LiFePO<sub>4</sub> batteries are less than half the weight of an equivalent SLA battery, has more useable capacity, can sit for long periods of time without losing much charge and has 4 times the life. The trade-off is price, but in the long-term they pay for themselves

- **Home / Base Operations**

- Weight is less of an issue so lead acid batteries have fewer disadvantages. Never use flooded batteries inside the house due to out-gassing. Need to keep them on a float charge when not in use
- LiFePO<sub>4</sub> batteries will have a much longer life and will be easier to move around, but are expensive, especially for occasional use

# Questions



KK6DAC@arrl.net