



# South County ARES

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\*

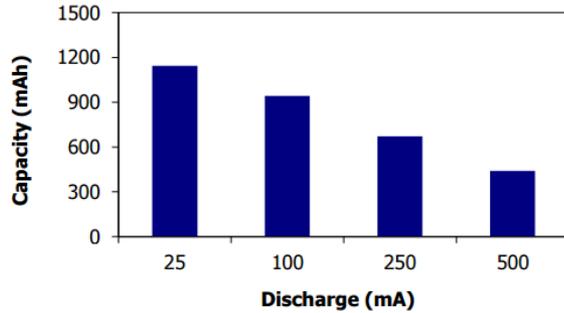


\*500 to 25 mA discharge current

# ALKALINE (ENERGIZER)

## Milliamp-Hours Capacity

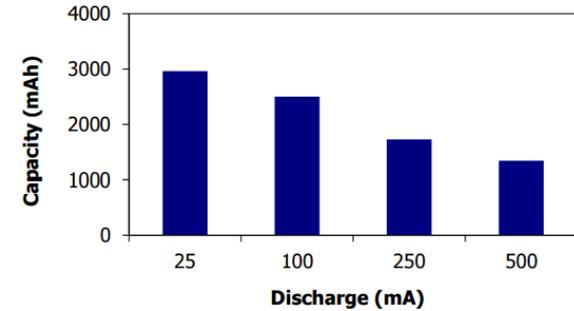
Continuous discharge to 0.8 volts at 21°C



AAA

## Milliamp-Hours Capacity

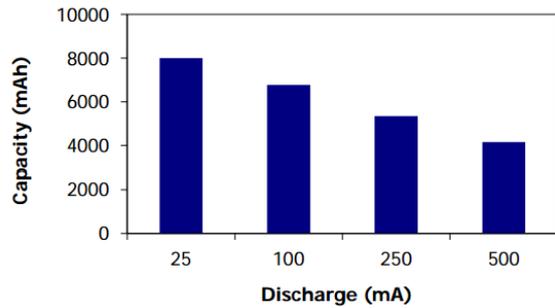
Continuous discharge to 0.8 volts at 21°C



AA

## Milliamp-Hours Capacity

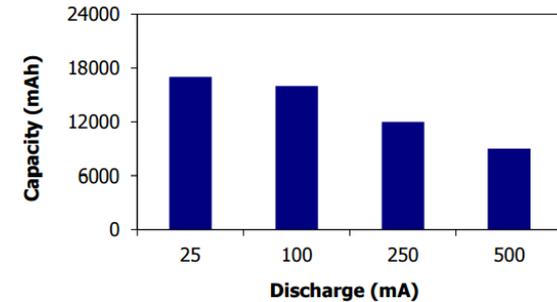
Continuous discharge to 0.8 volts at 21°C



C

## Milliamp-Hours Capacity

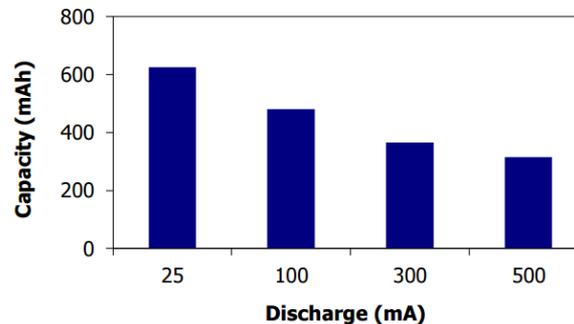
Continuous discharge to 0.8 volts at 21°C



D

## Milliamp-Hours Capacity

Continuous discharge to 4.8 volts at 21°C



9v

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

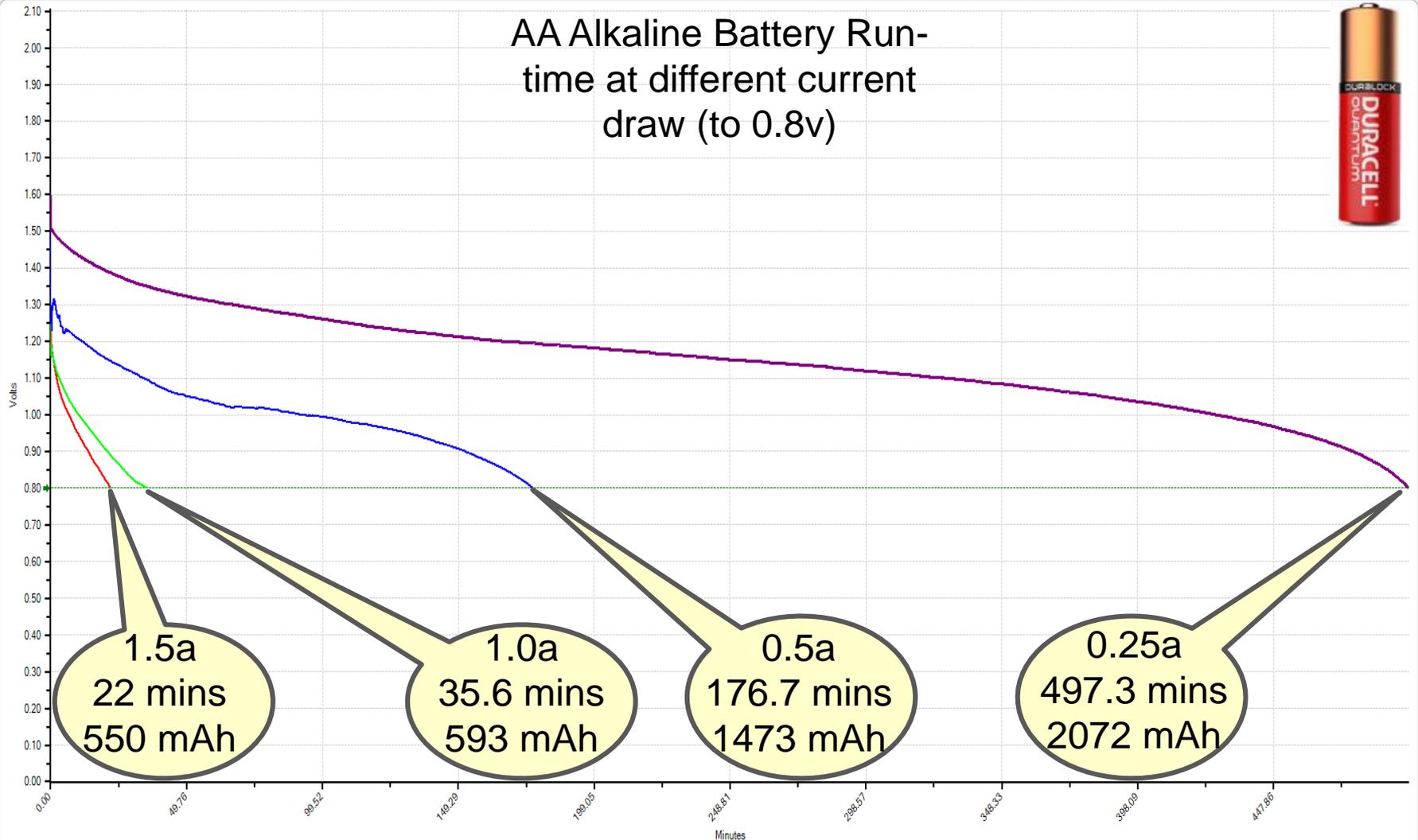
# ALKALINE (PEUKERT'S LAW)

- Peukert's Law – In lead acid batteries, as the discharge amps increase, 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



Voltage  
1.16

Current  
.

AmpHr  
2.072

Watts  
.

Status  
Done

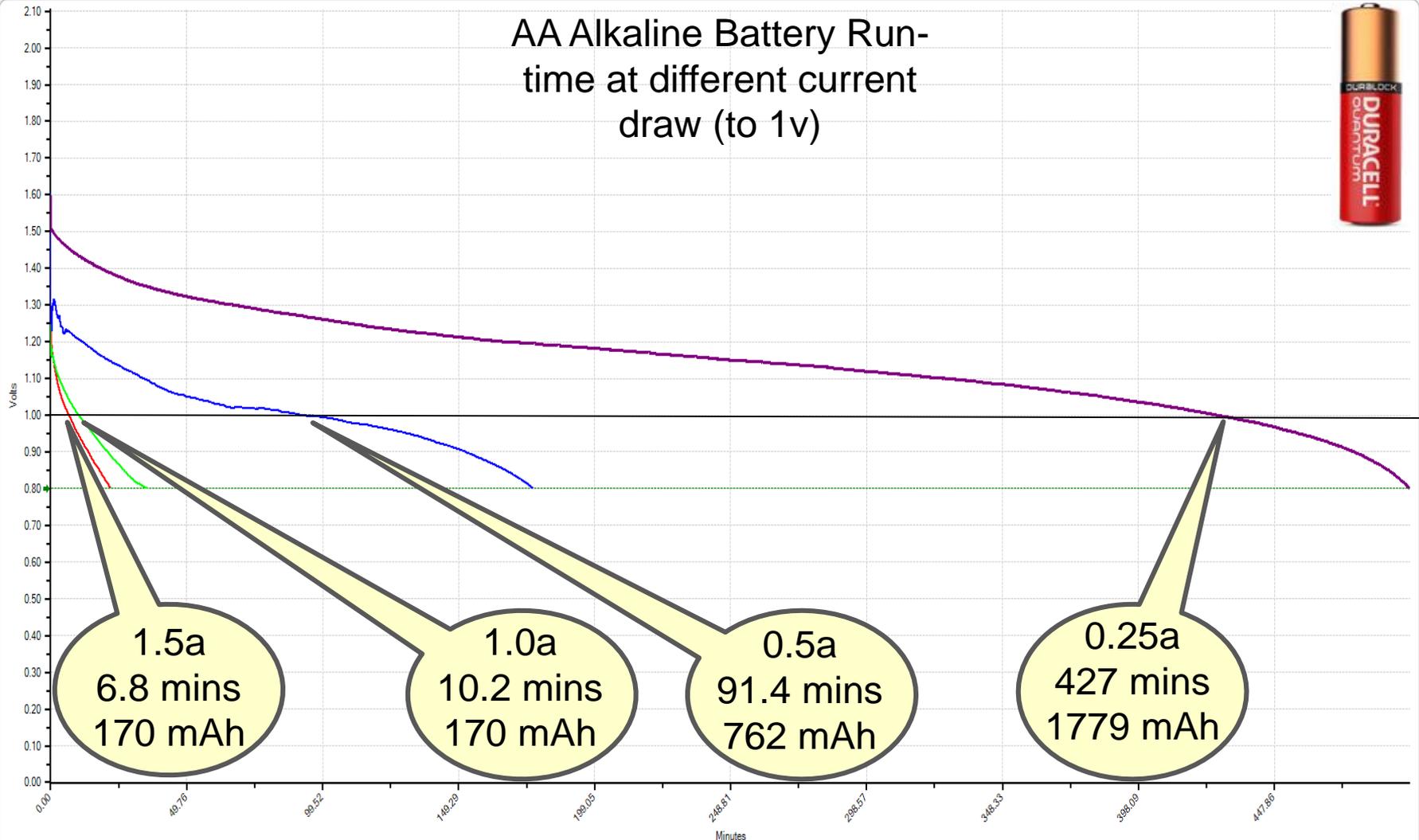
Resistance  
3.19

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# 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



Voltage

1.16

Current

.

AmpHr

2.072

Watts

.

Status

Done

Resistance

3.19

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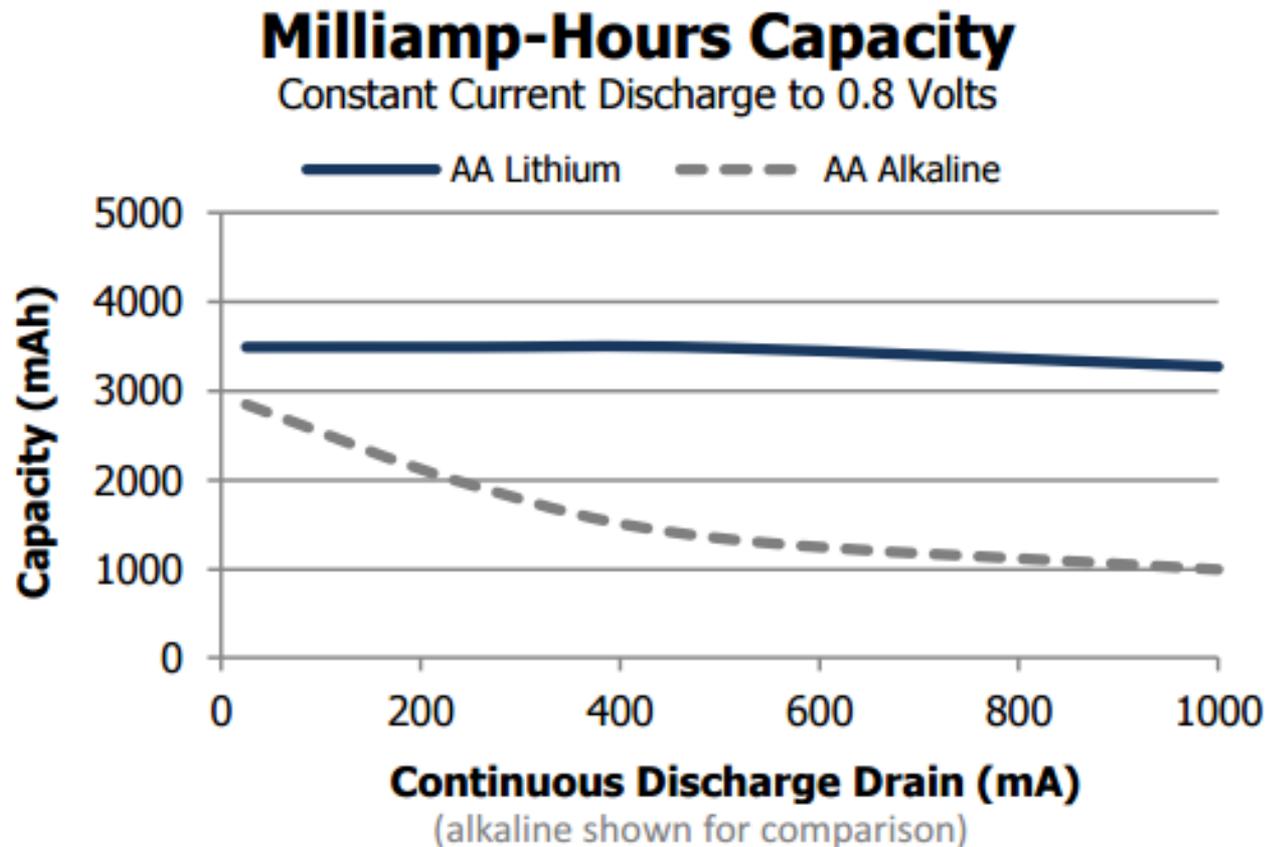
# PRIMARY LITHIUM

- **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/>

# 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



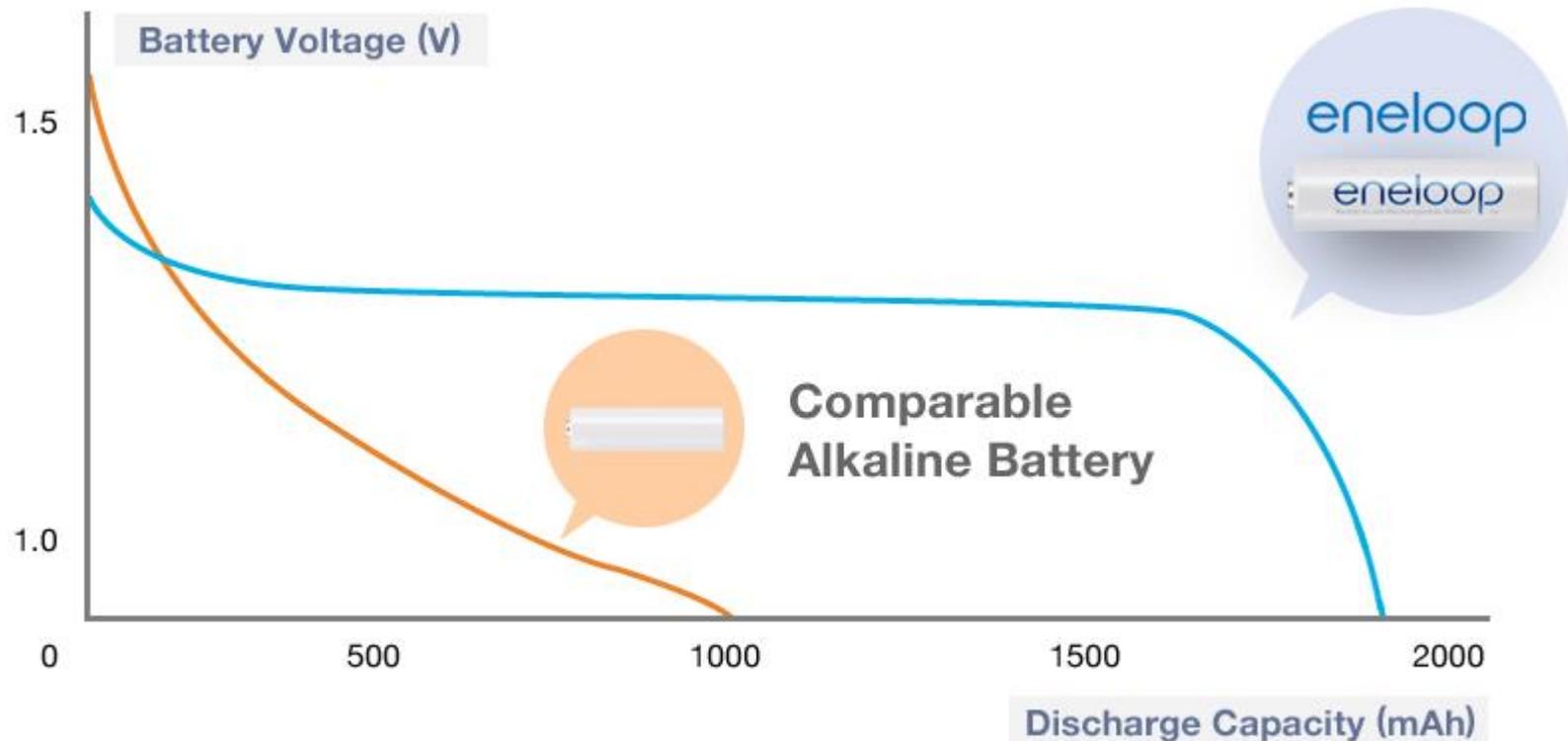
# NICKEL METAL HYDRIDE (NIMH)

- **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 continuous discharge



Source: <https://www.panasonic.com/global/consumer/battery/eneloop/technologies.html>

# 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
  - Used in the Tesla Automobiles and Battery Wall

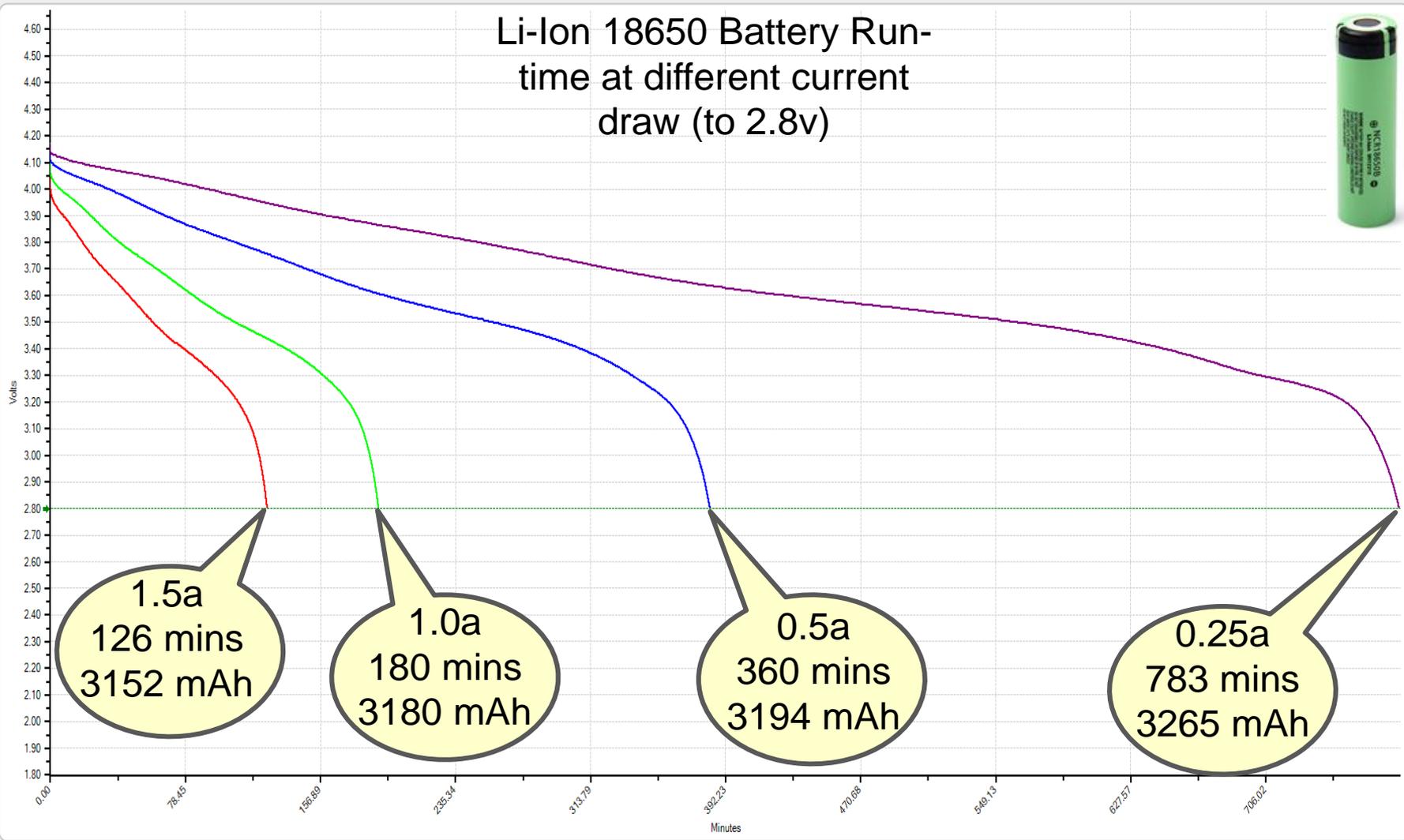


# LI-ION 18650 (PANASONIC)

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: 3.05  
Current: .  
AmpHr: 3.265  
Watts: .  
Status: Done  
Resistance: 5.48

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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

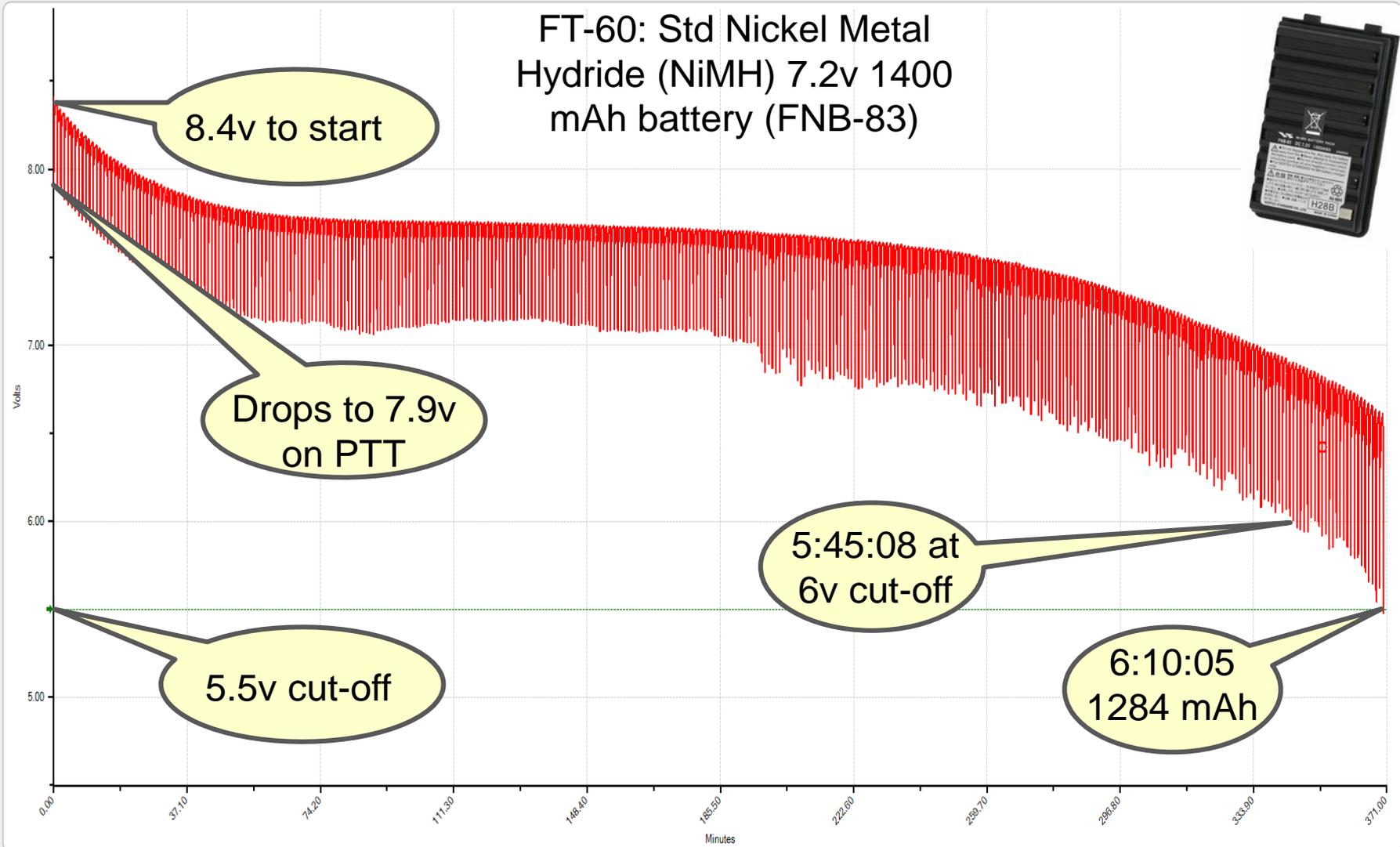
- **Used the Multi-Discharge test using the following settings**
  - Low-Voltage cut-off: 5.5v
  - 1s steps until cut-off voltage is met
  - Three step discharge
    - 5s @ 1.6a (transmit)
    - 22s @ 0.2a (receive)
    - 33s @ 0.02a (idle)
- **All primary/single-use batteries were “fresh”**
- **All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

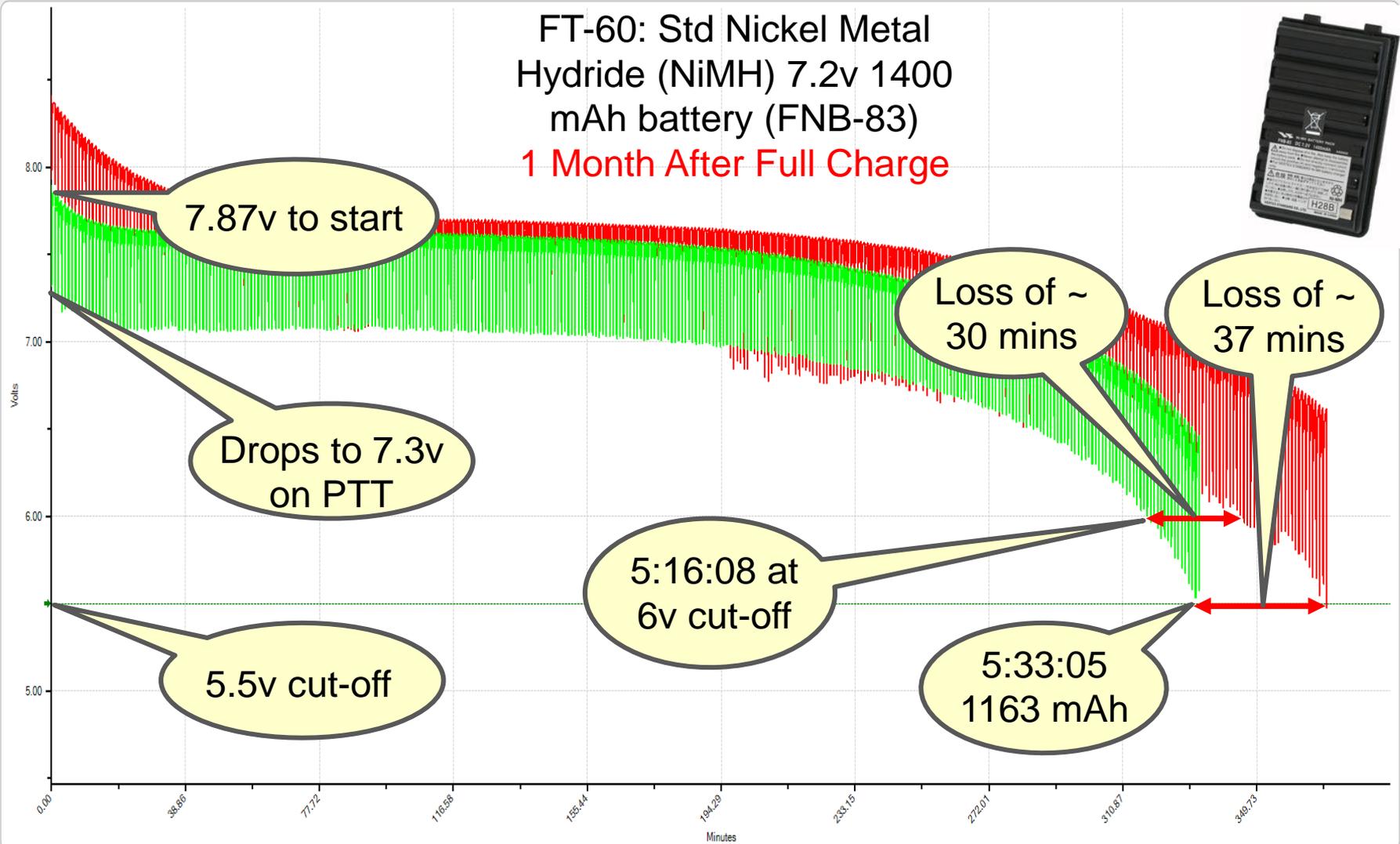
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# TEST RESULTS

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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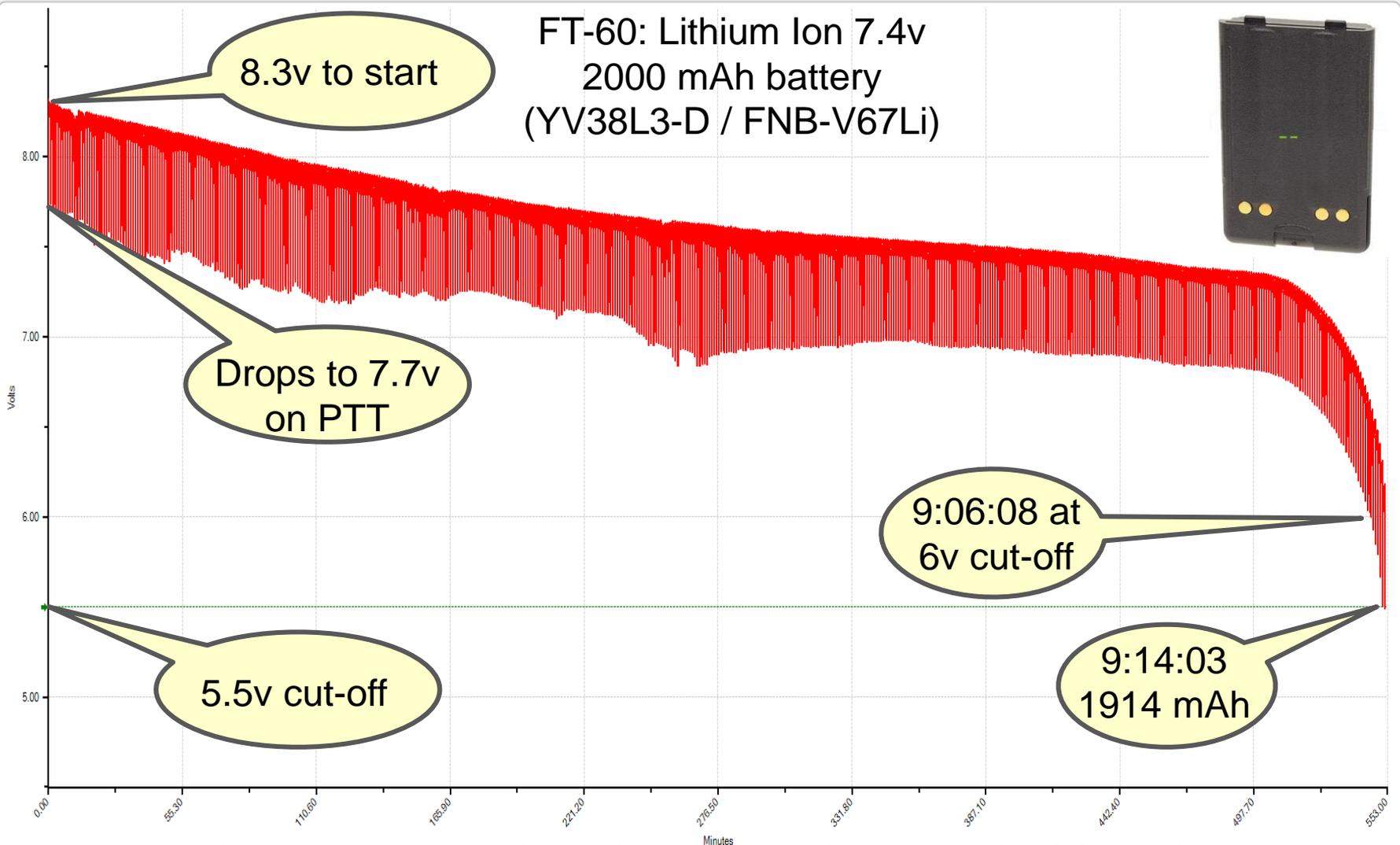
27

# TEST RESULTS

FT60 - Li-Ion 2500 mAh.bt2

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

FT-60: Lithium Ion 7.4v  
2000 mAh battery  
(YV38L3-D / FNB-V67Li)



Voltage

6.90

Current

.

AmpHr

1.914

Watts

.

Status

Done

Resistance

2.00

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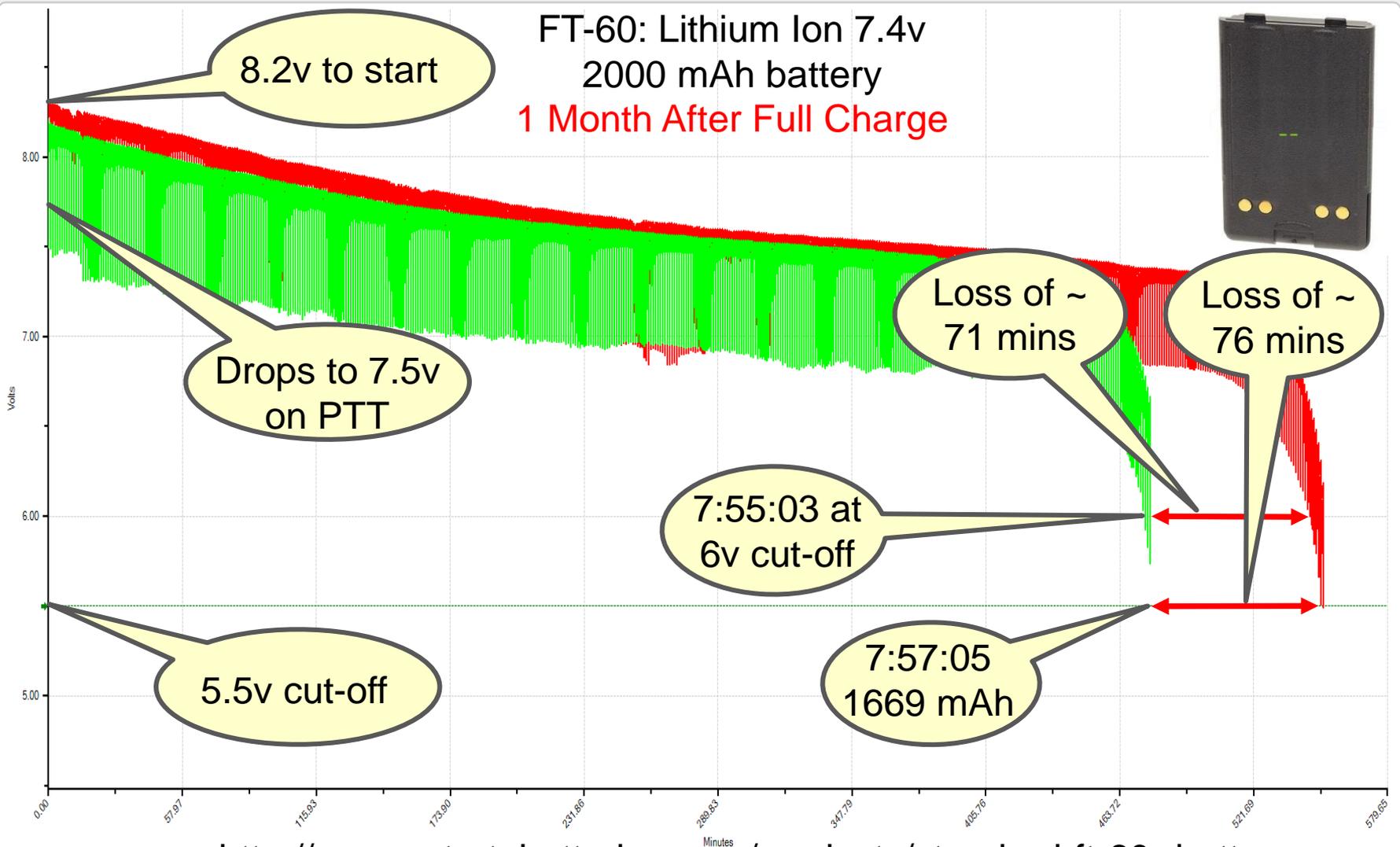
<http://www.cutratebatteries.com/products/standard-ft-60r-battery>

# 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

FT-60: Lithium Ion 7.4v  
2000 mAh battery  
1 Month After Full Charge



Voltage  
7.33

Current  
.

AmpHr  
1.669

Watts  
.

Status  
Done

Resistance  
3.72

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<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*



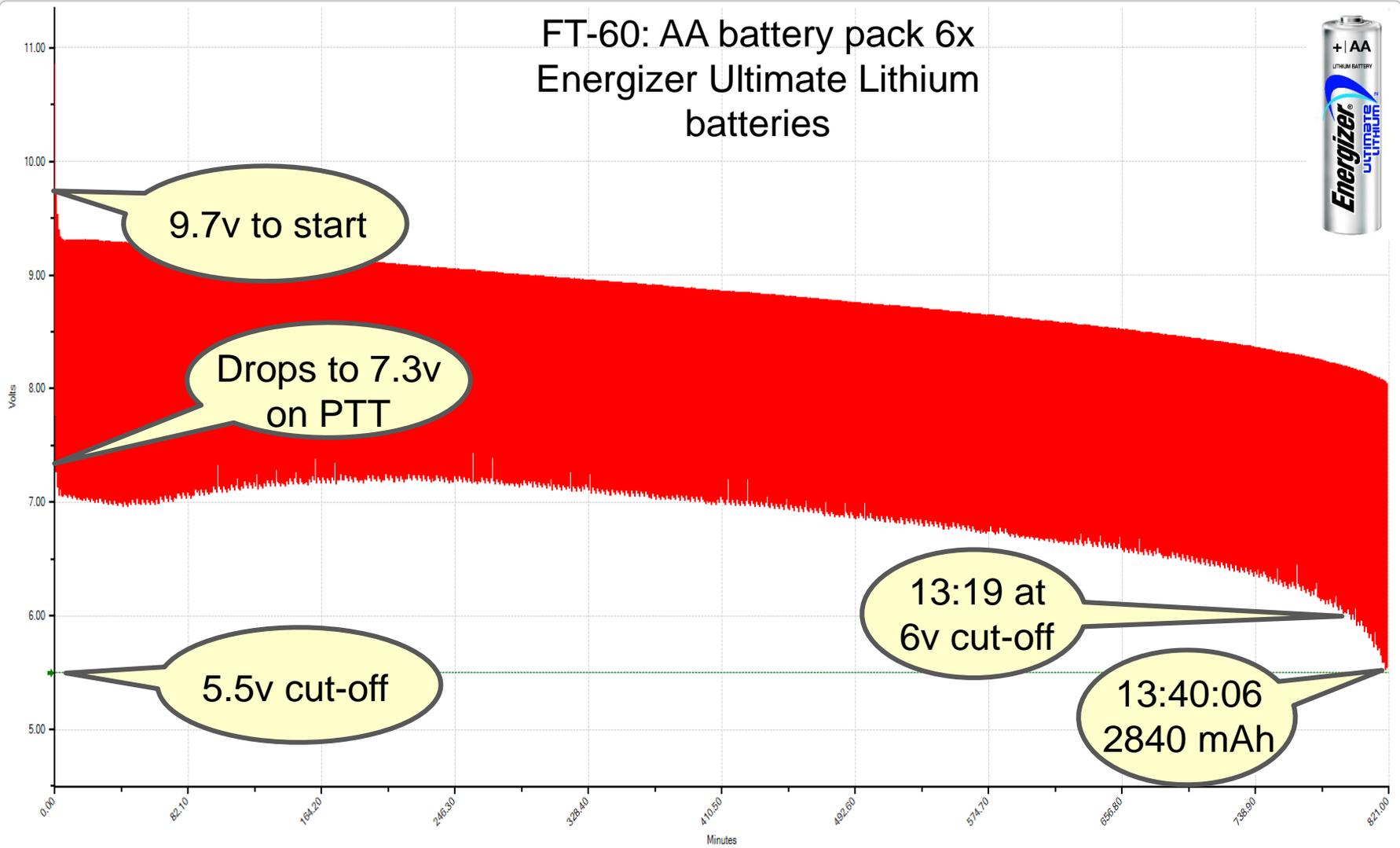


# TEST RESULTS

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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32

# TEST RESULTS

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



\$9.00 / 3 oz

# TEST RESULTS

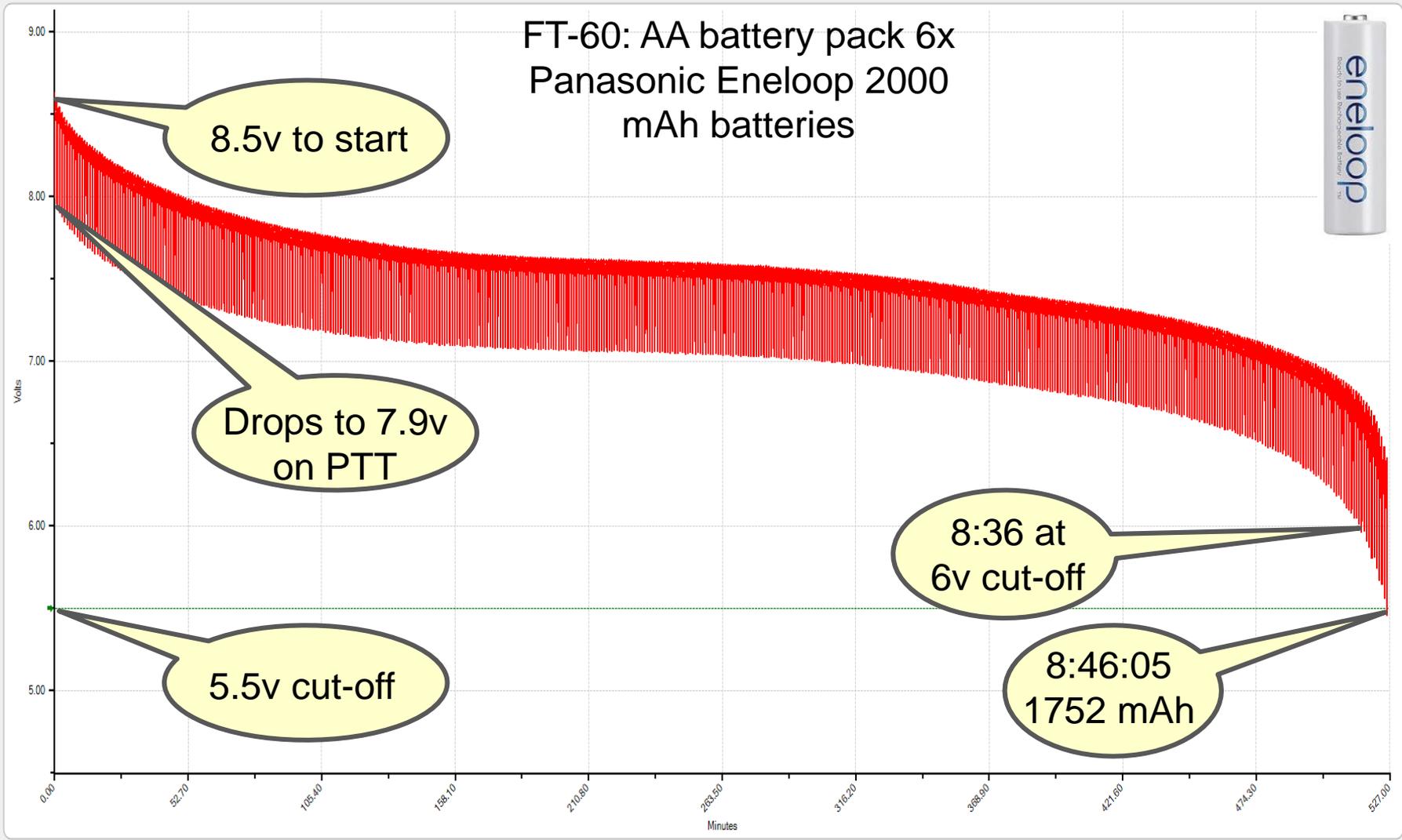
Yaesu FT-60 Operating Manual – Page 10

## 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



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



# TEST RESULTS

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



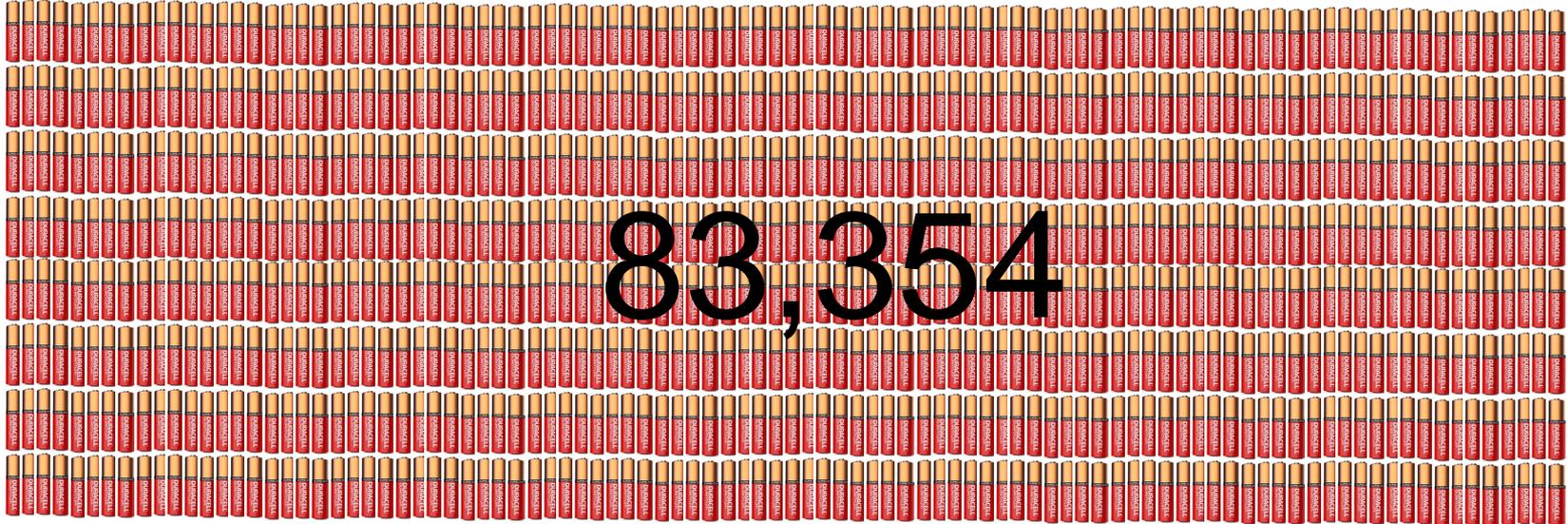
But wait, the Eneloop's are rechargeable up to 2100 times



\$12.00 / 2.7 oz

# TEST RESULTS

\$58,320 / 2.43 tons



83,354

==



\$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



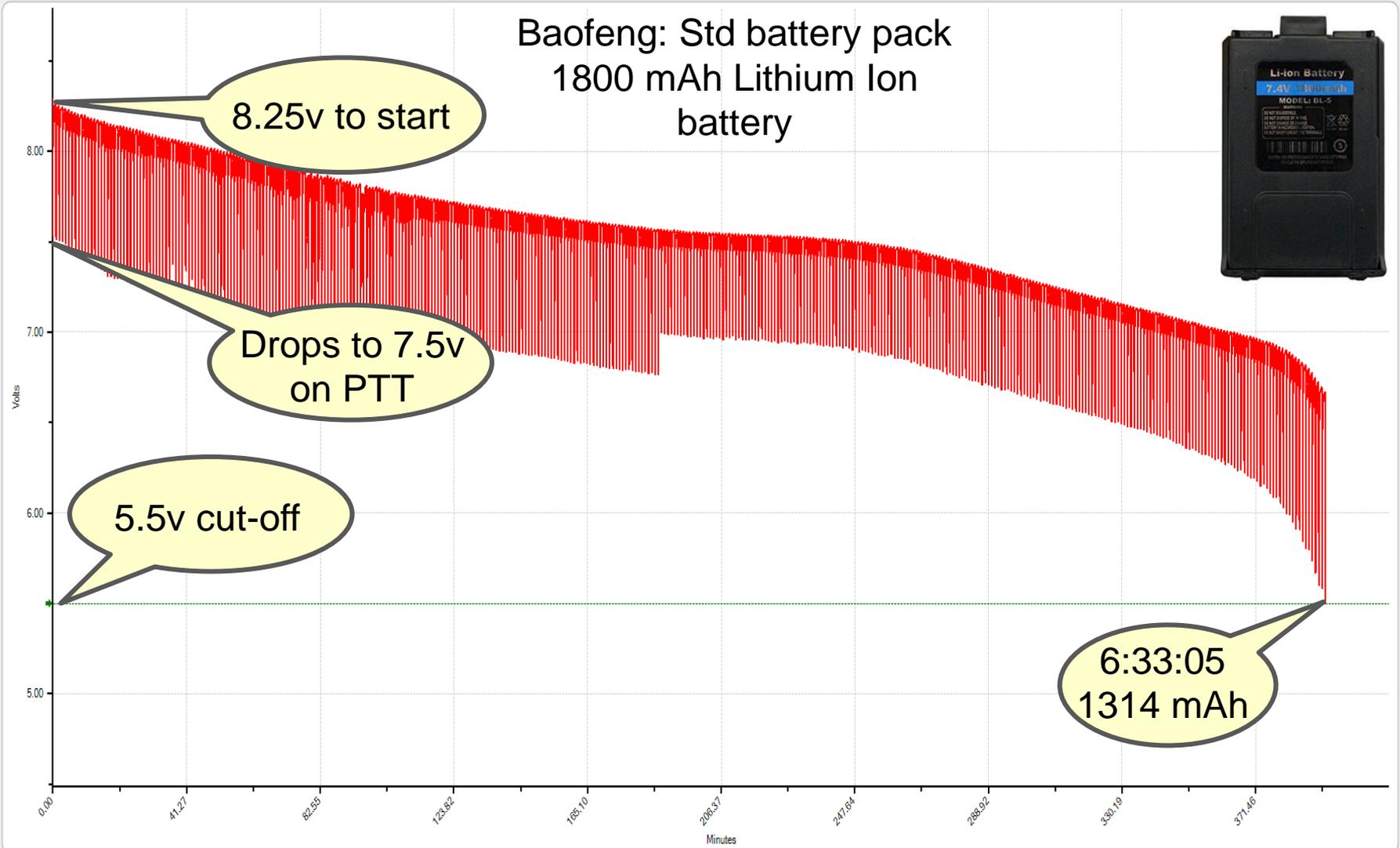
\$12.00 / 2.7 oz  
(plus \$50.40 to recharge  
then 2100 times)

- 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

1.314

Watts

.

Temp

.

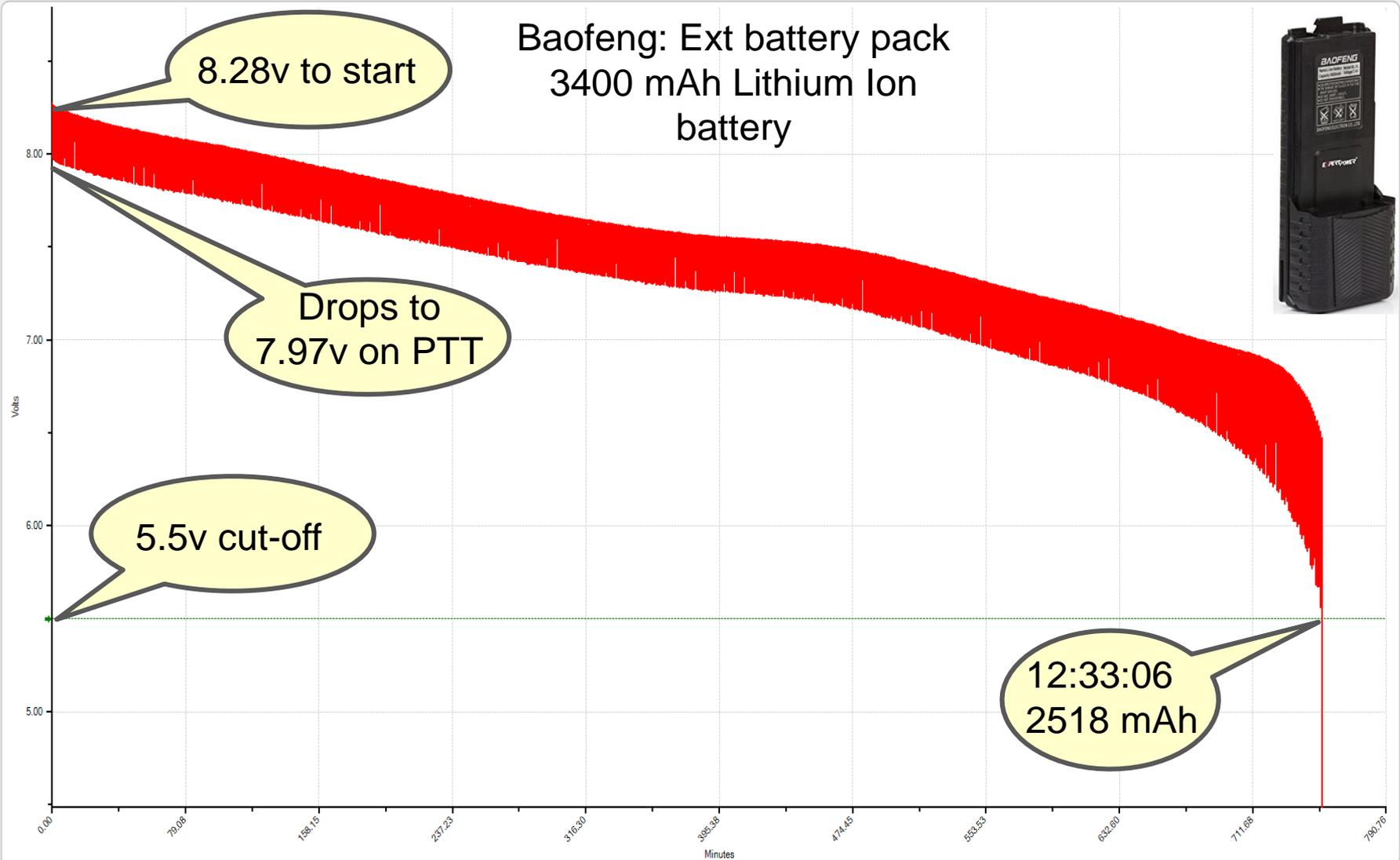
Status

.

# 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)



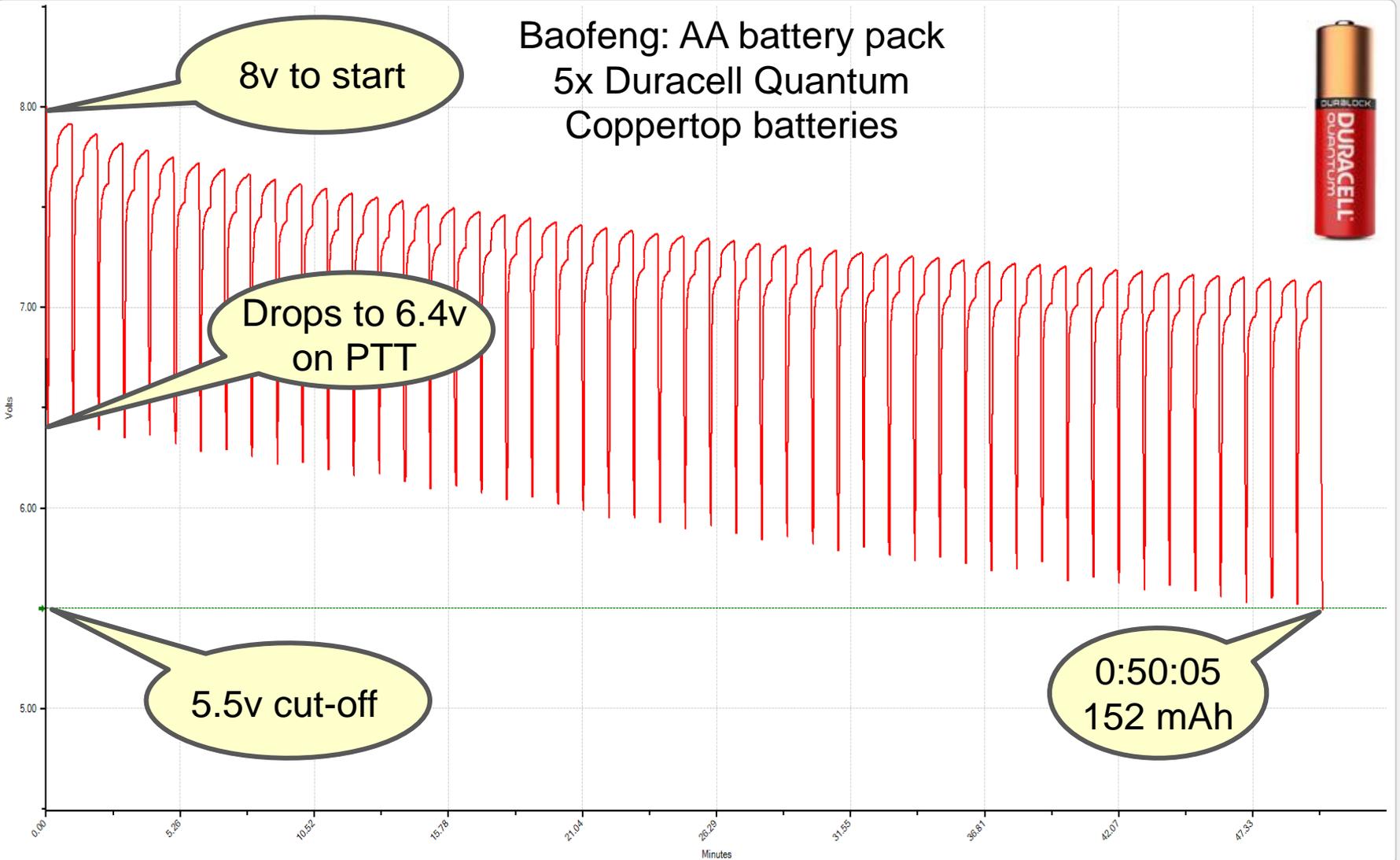
**BAOFENG TECH** The AA Battery Pack will work with all styles of AA Batteries:  
Depending on the AA Battery will determine how to use:  
**Normal Alkaline AA Batteries:**  
Use 5 AA Alkaline and 1 Dummy AA (included)  
*If you use 6 AA Alkaline or Zinc Carbon cells, the receiver will work but the radio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



# TEST RESULTS

AA-Duracell-5x-Baofeng.bt2

Baofeng Alkaline: 5 Alkaline cells Multiple Discharge Profile



Voltage

Current

AmpHr

0.152

Watts

Temp

Status

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# TEST RESULTS

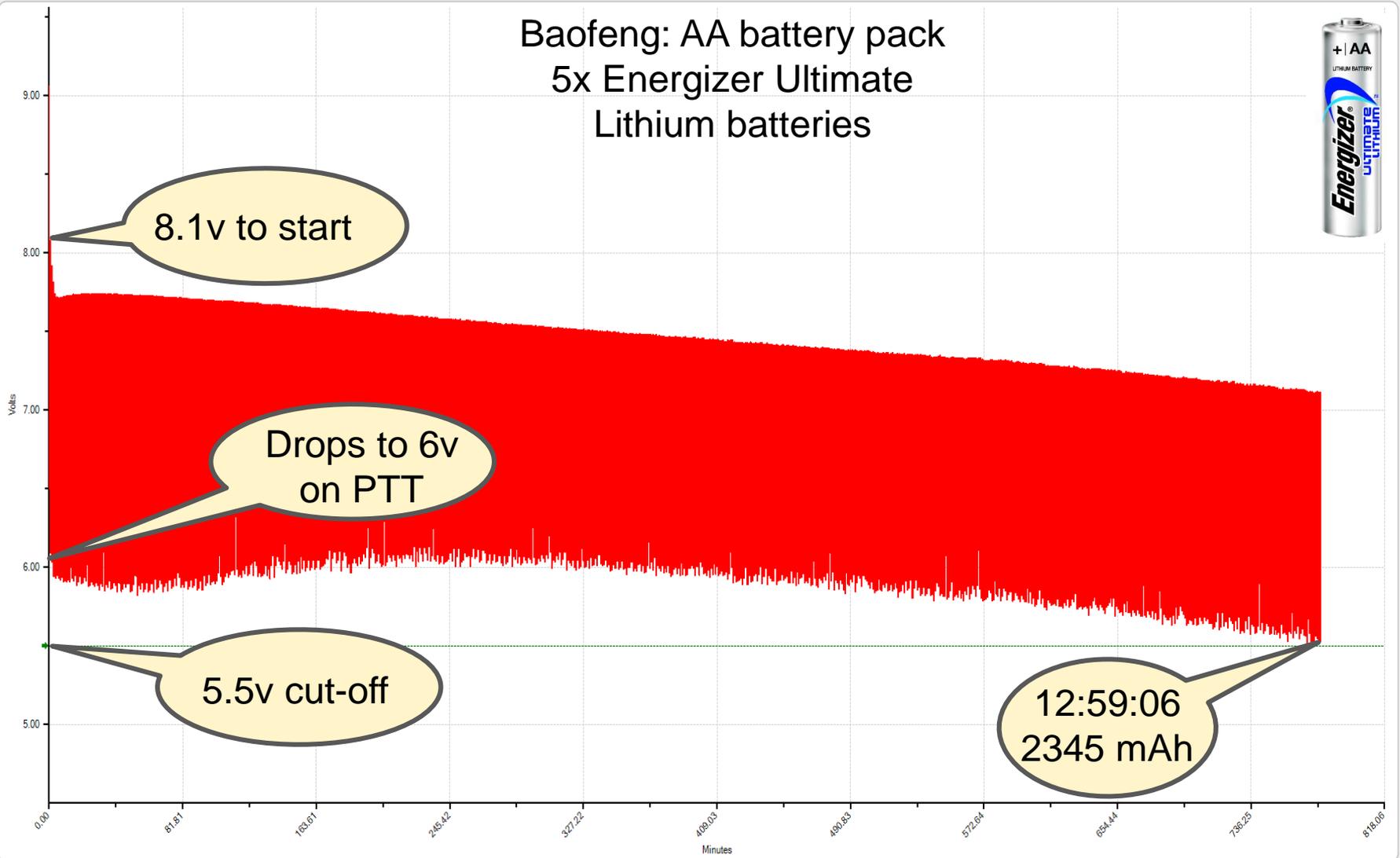
rgizer-Ultimate-Lithium-5x-Baofe

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

Baofeng: AA battery pack  
5x Energizer Ultimate  
Lithium batteries



Voltage  
Current  
AmpHr 2.345  
Watts  
Temp  
Status

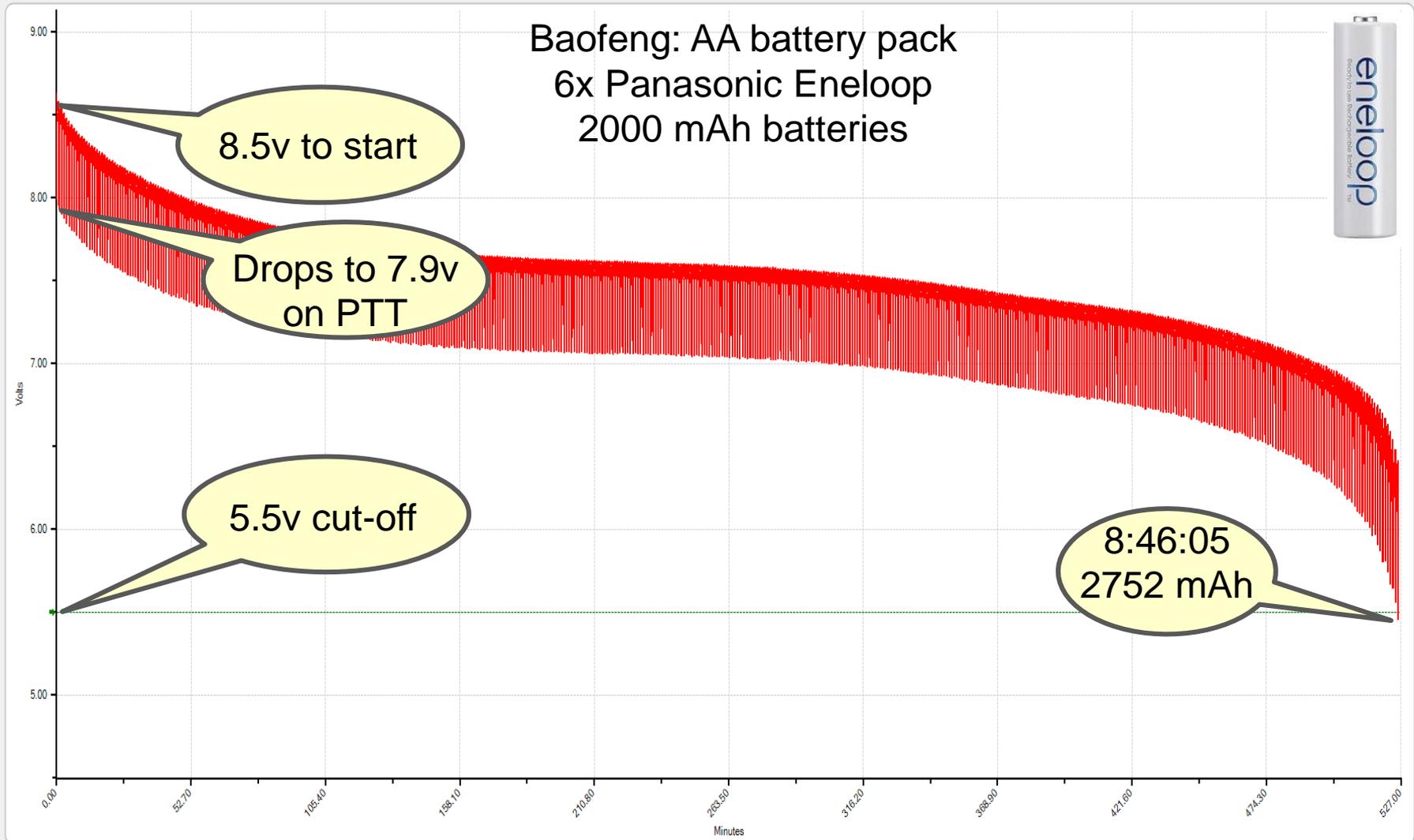


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# TEST RESULTS

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

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



Voltage

7.16

Current

.

AmpHr

1762

Watts

.

Status

Done

Resistance

2.12

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# 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

# 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**

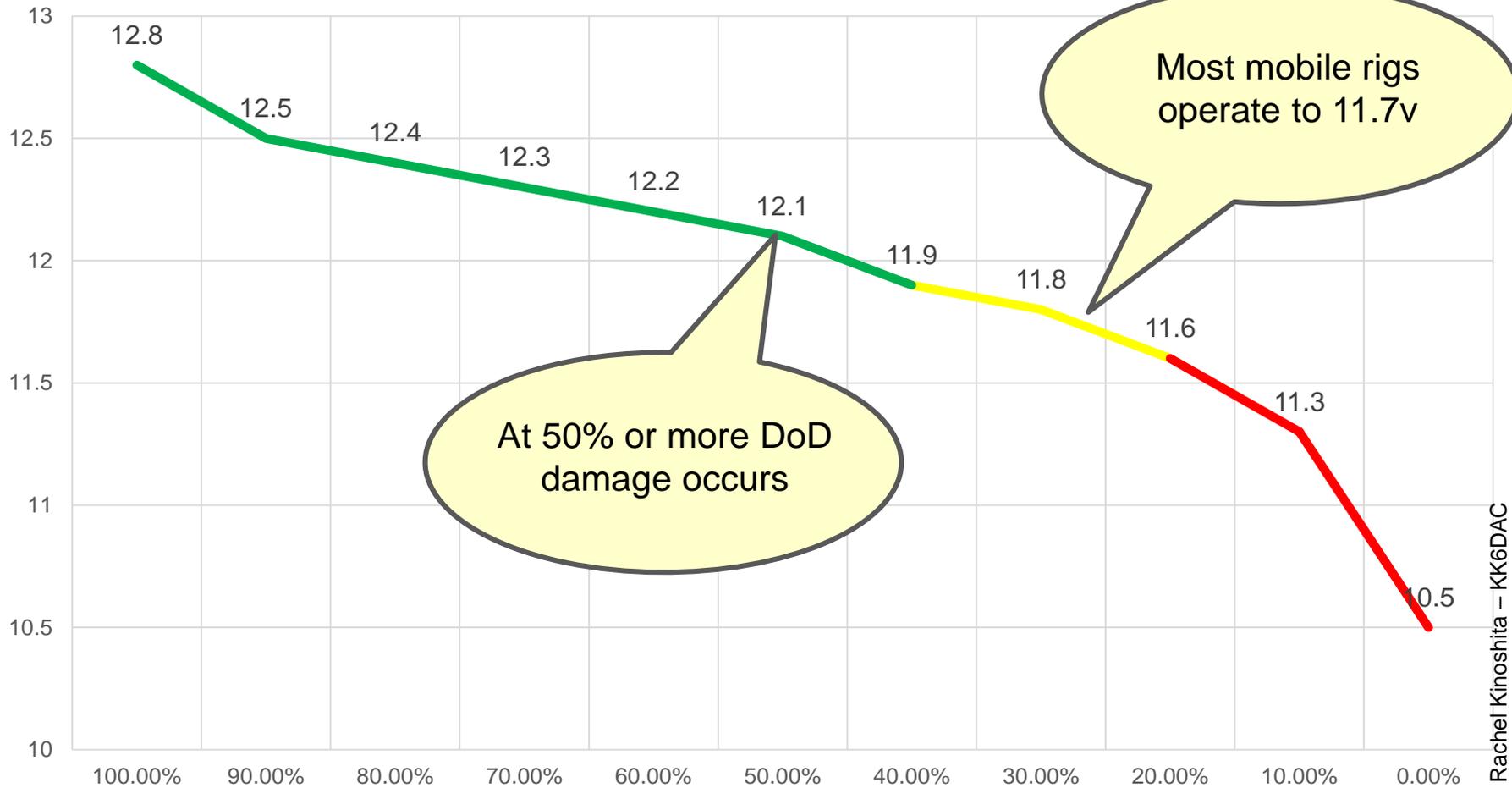
- Flooded (Automobile starter, Maintenance free, Deep cycle, Golf cart batteries)
  - Proven technology
  - Relatively inexpensive
- Sealed/Gel
  - No outgassing
  - Can be installed in any position
- Absorbed Glass Matte (AGM)
  - No outgassing
  - Can be installed in any position
  - Relatively long 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 (LIFEPO4)

- **Pros**

- Very low self-discharge
- Relatively flat discharge curve
- Can be recharged thousands of times
- Will not leak
- No outgassing
- High energy density
- Unlike Li-Ion, LiFePO4 is very safe
- Can be field charged using a lead acid battery charger
- Peukert constant = 1.01 or less

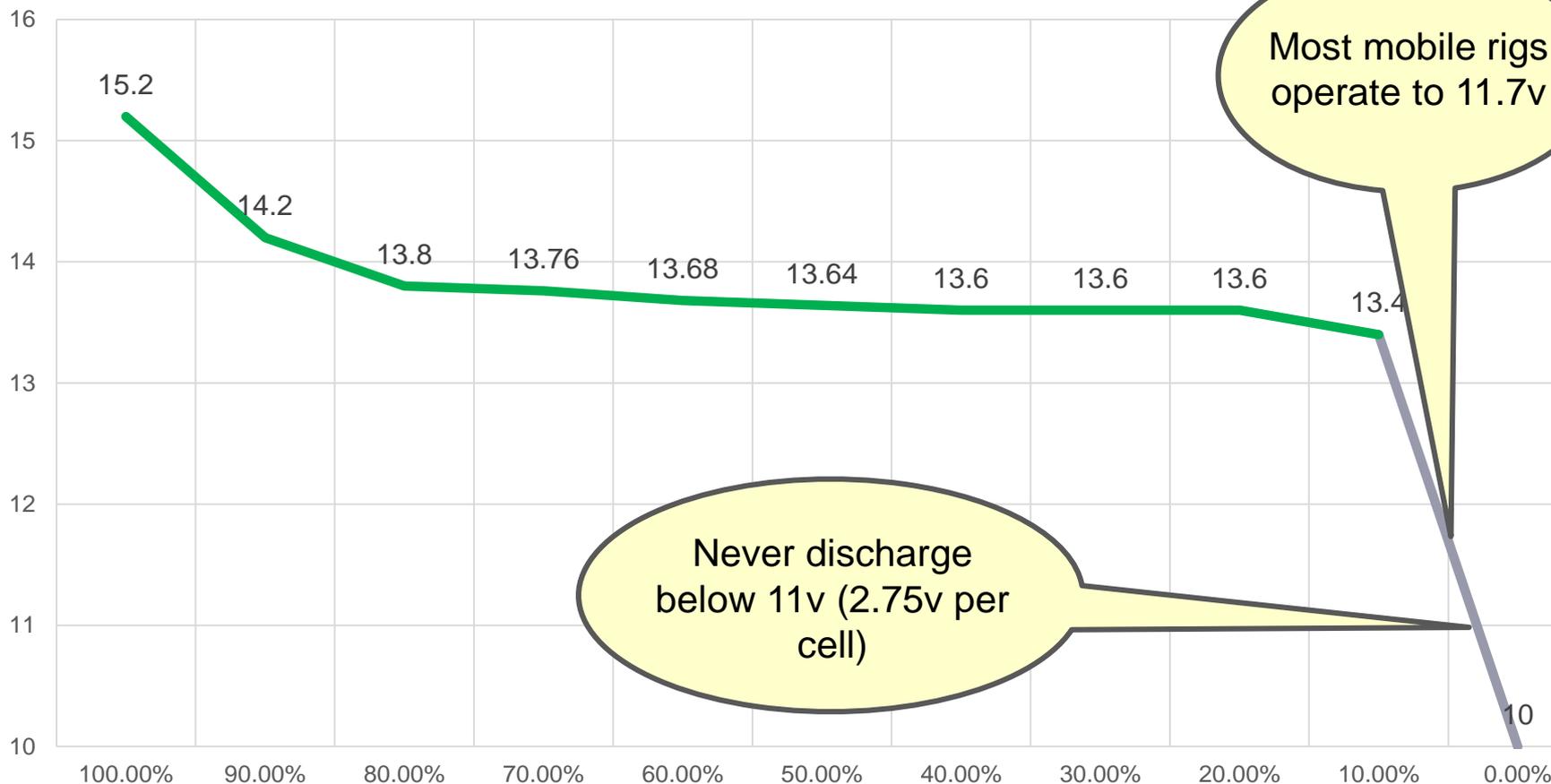
- **Cons**

- Expensive
- Must balance the cells using a proper LiFePO4 charger



# LITHIUM IRON PHOSPHATE (LIFEPO4)

LiFePO4 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**

Mobile radios typically draw around 13A at 50w xmit. However this is the max amp draw for the CBA IV

# 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)

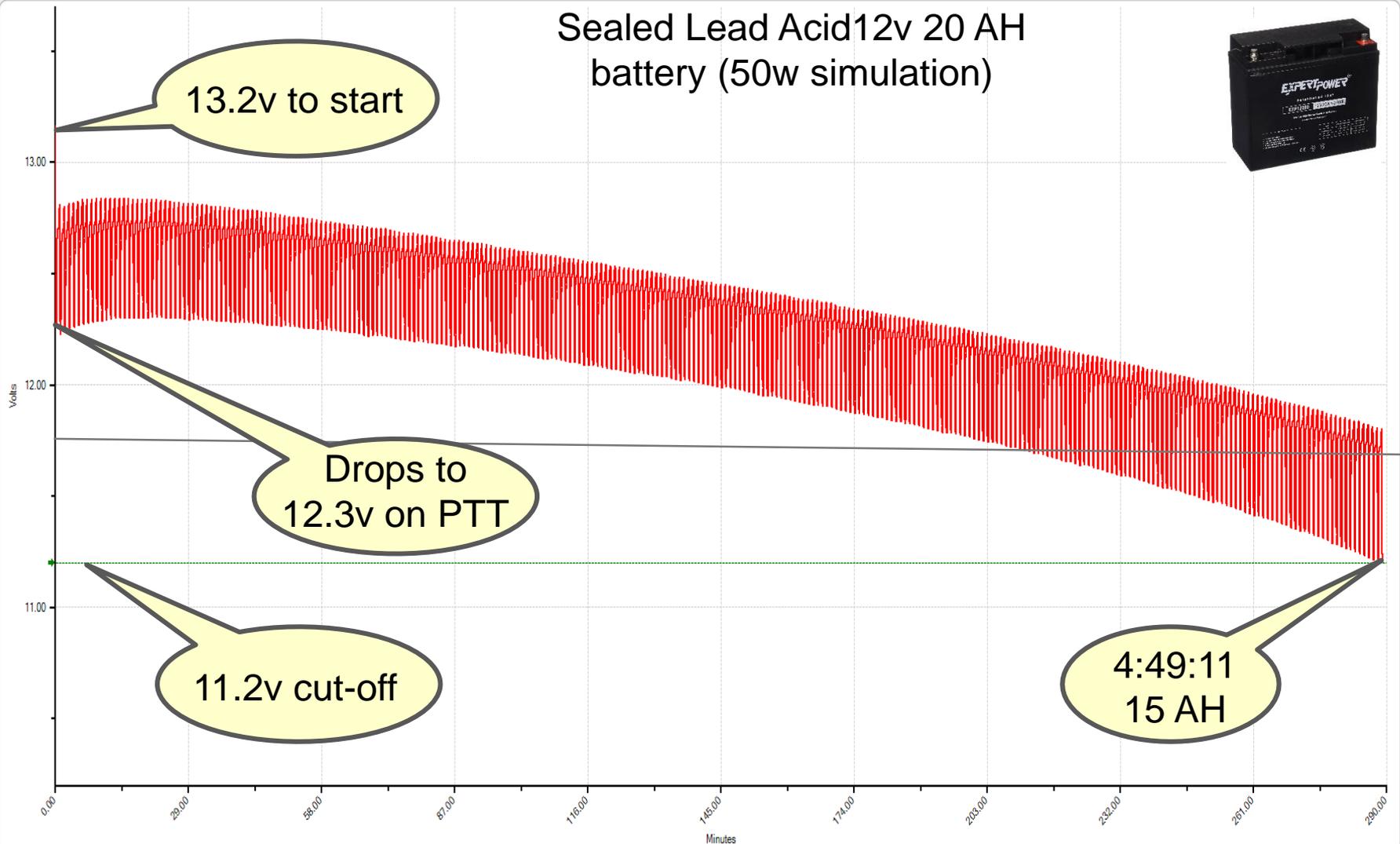


13.2v to start

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

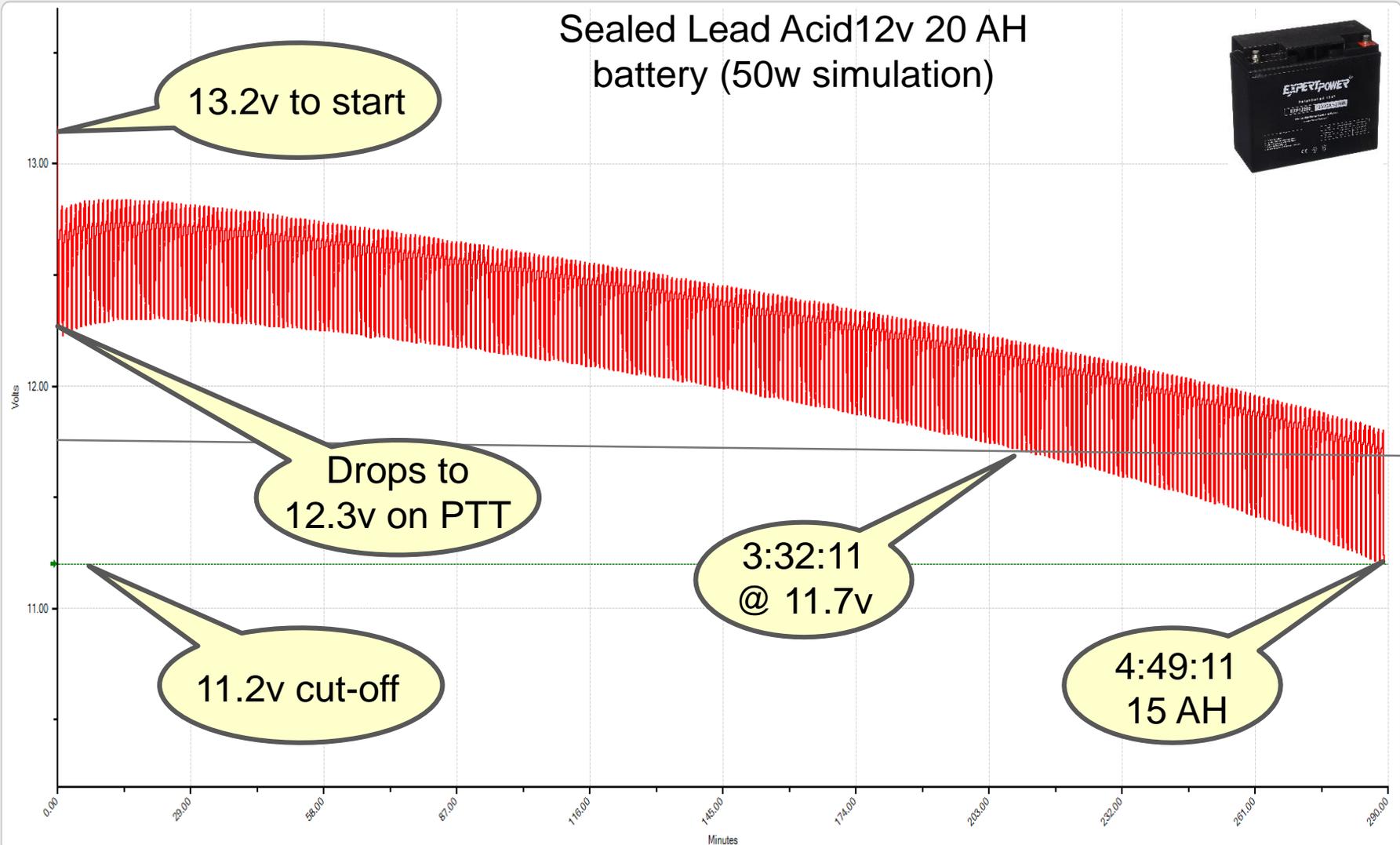
55

# 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

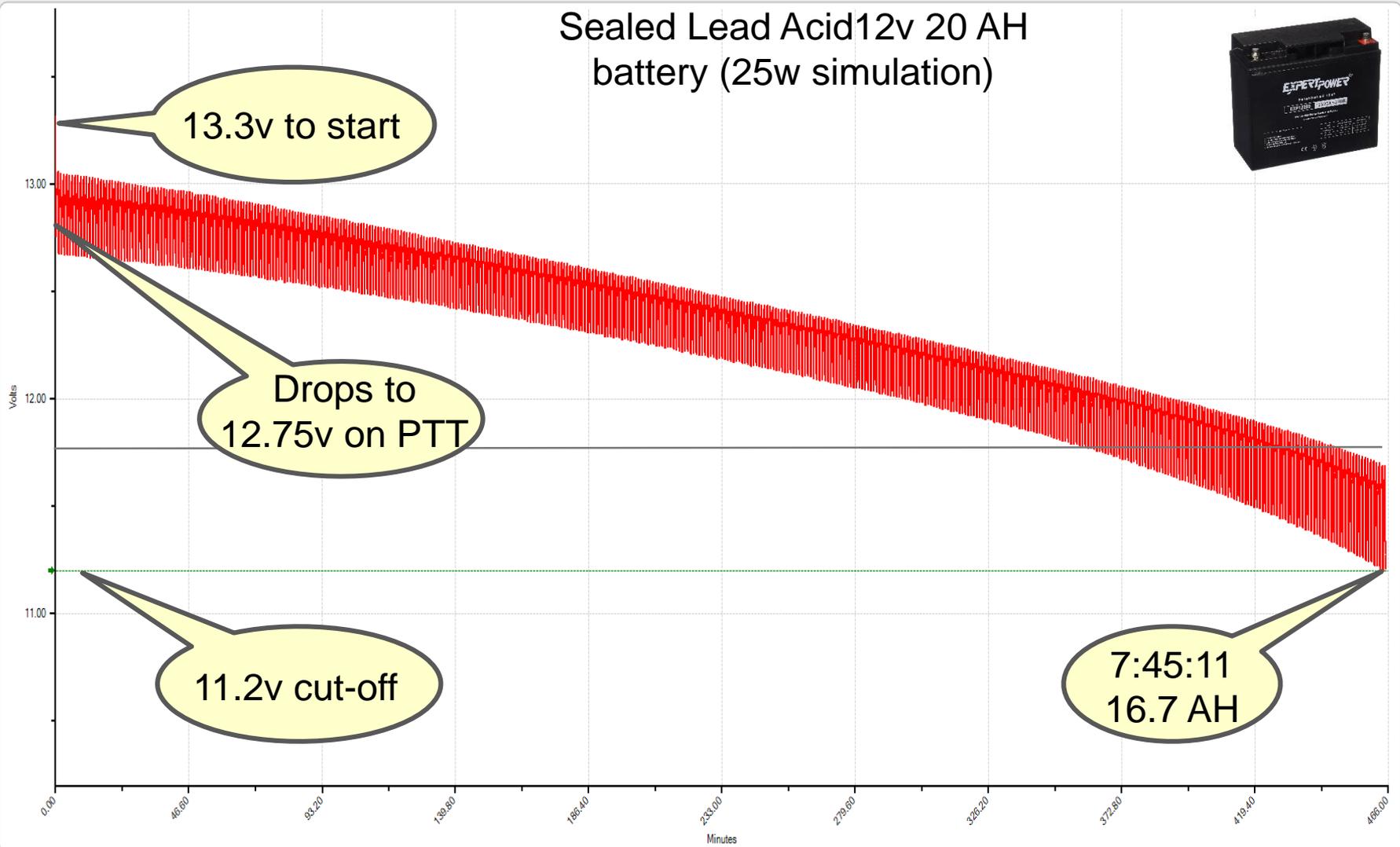
56

# 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

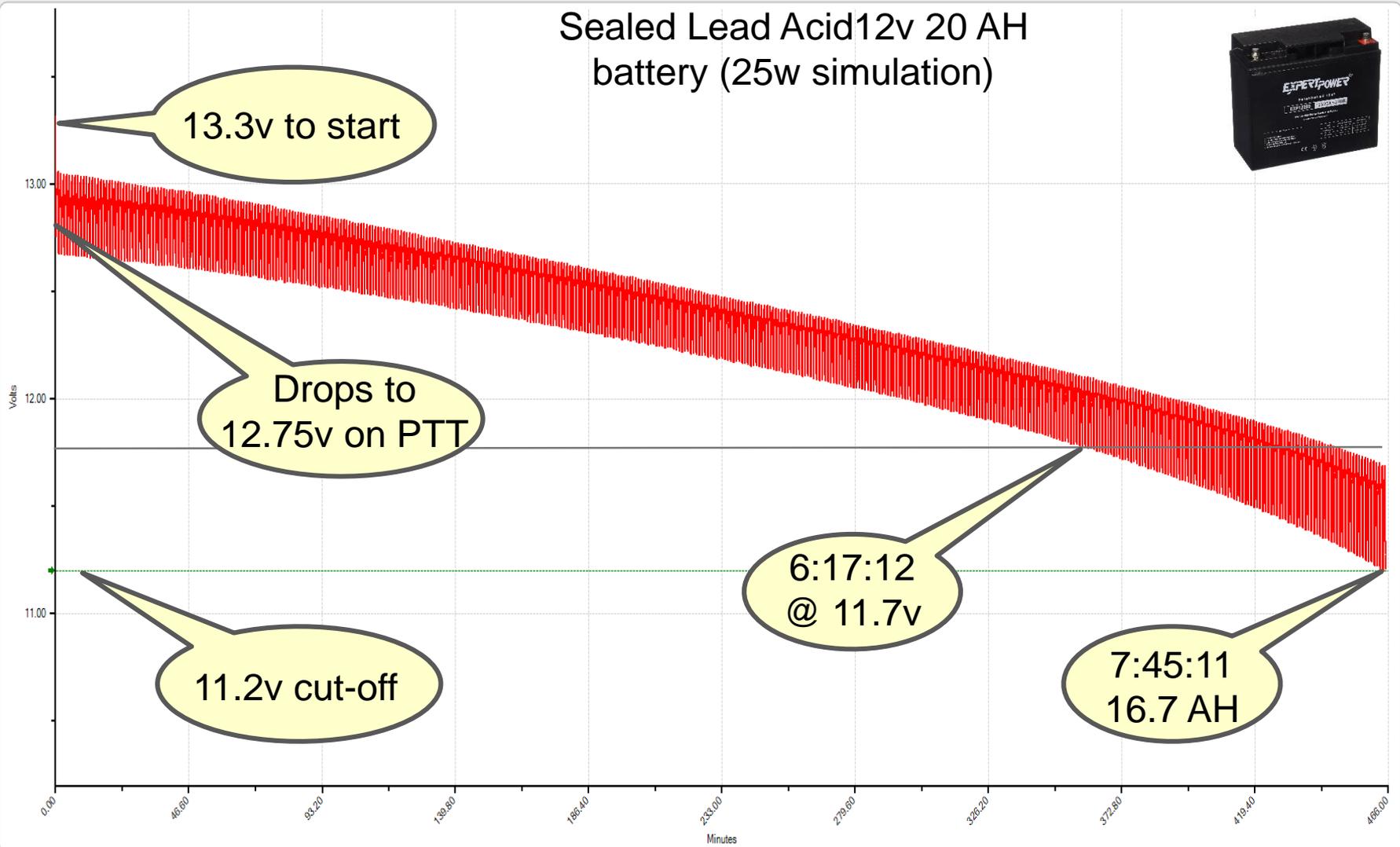
Rachel Kinoshita - KK6DAC

# 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  
  
Current  
  
AmpHr  
  
Watts  
  
Status  
  
Resistance

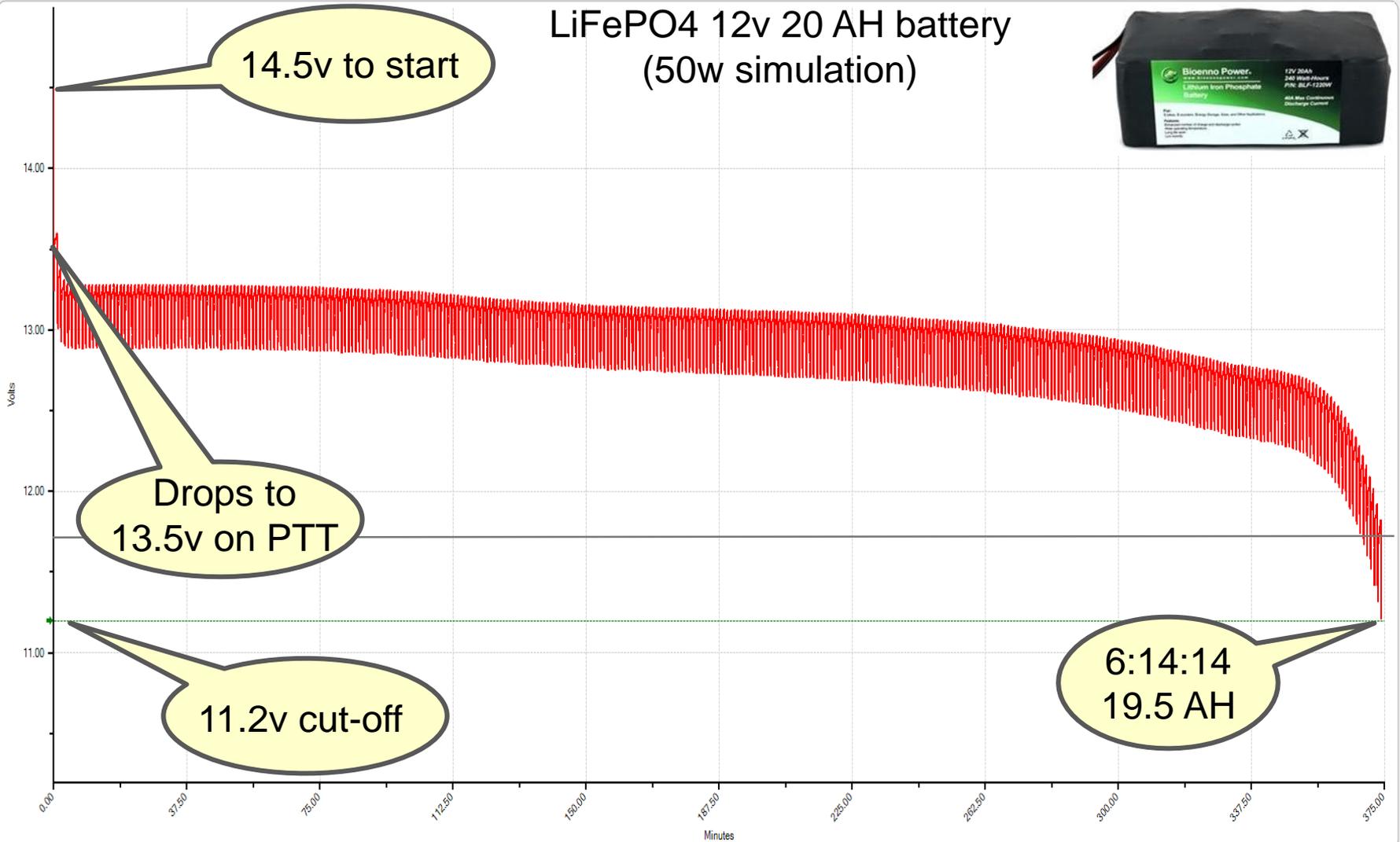
Rachel Kinoshita - KK6DAC

# 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

Rachel Kinoshita - KK6DAC

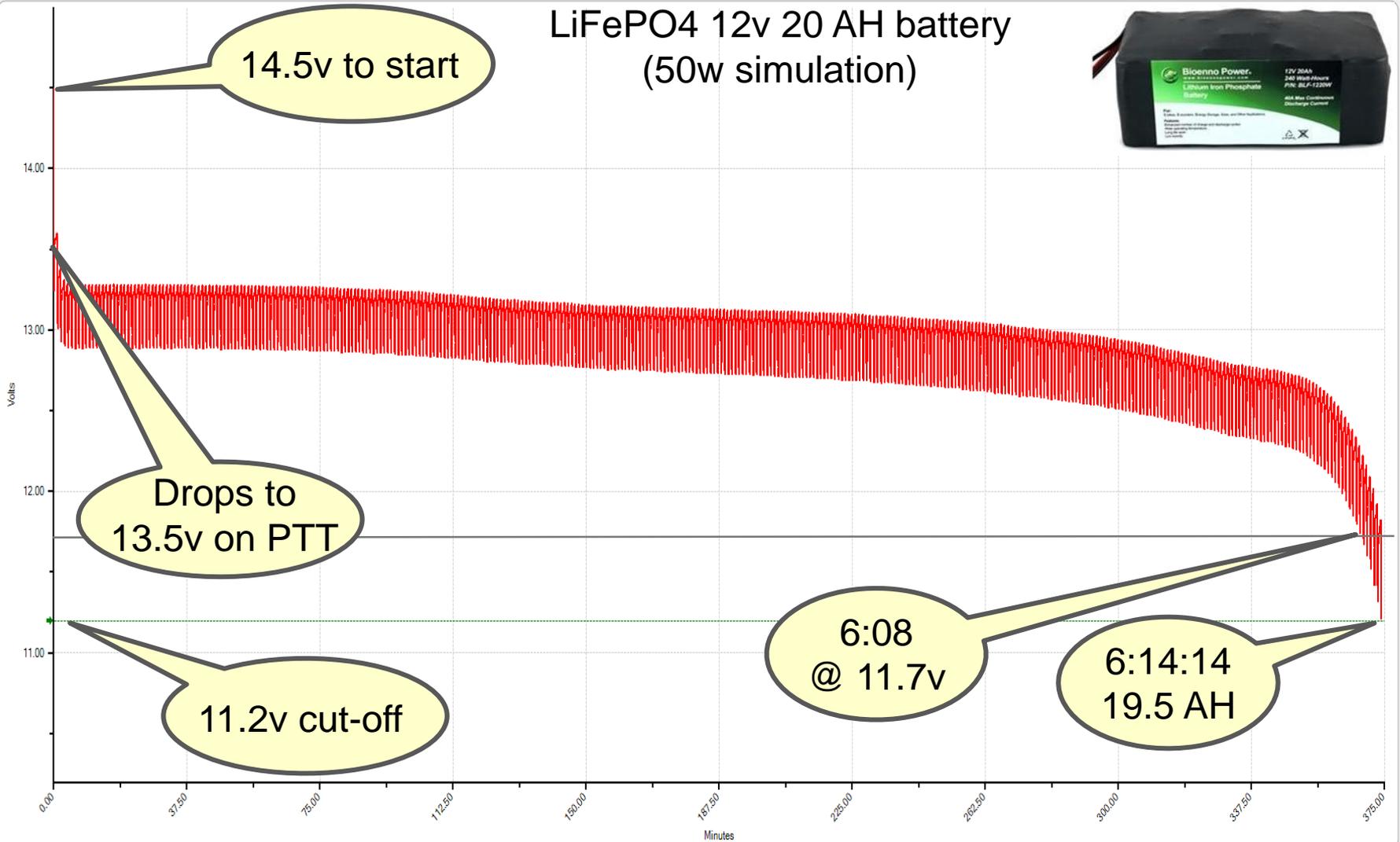
59

# 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

Rachel Kinoshita - KK6DAC

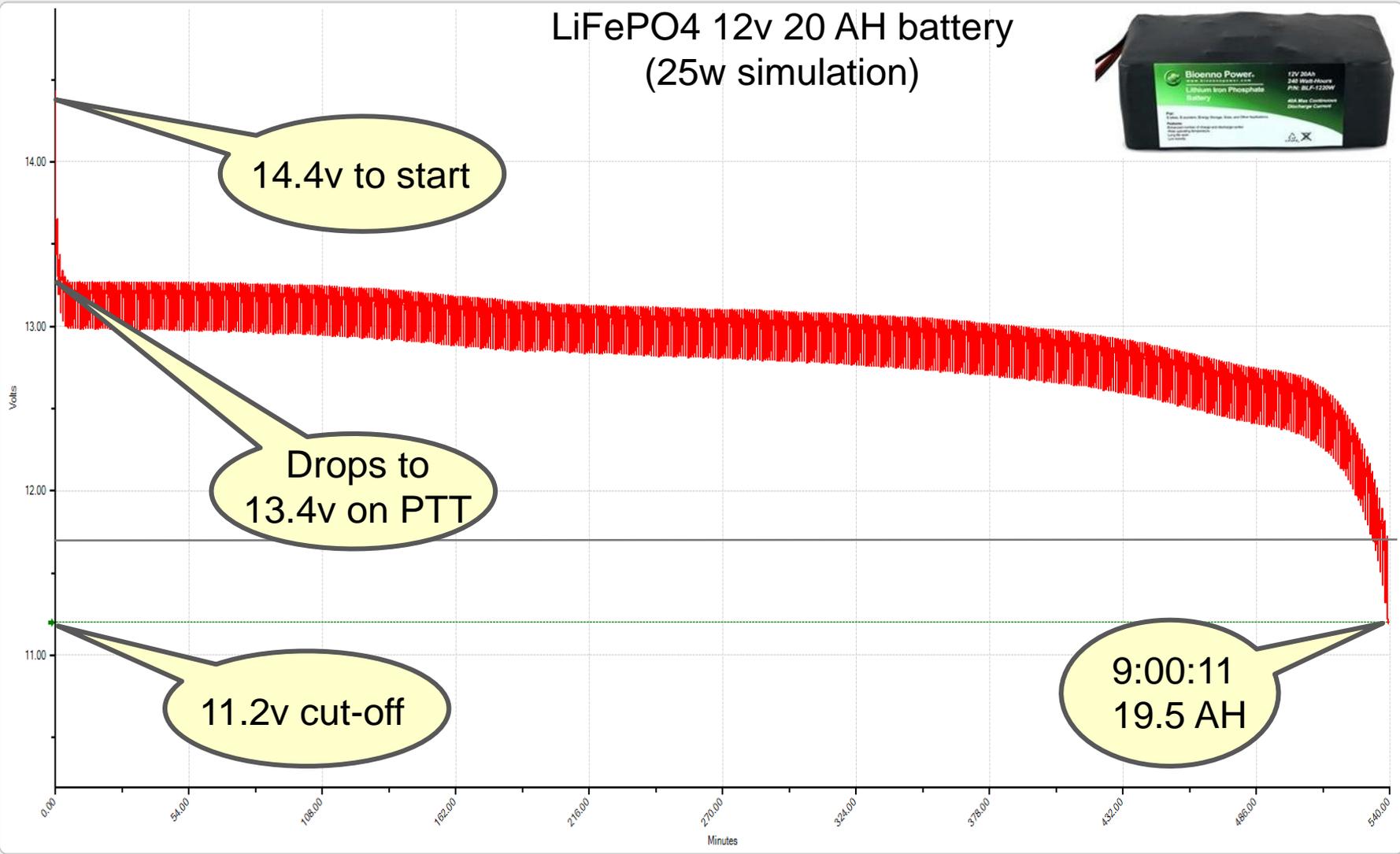
60

# 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

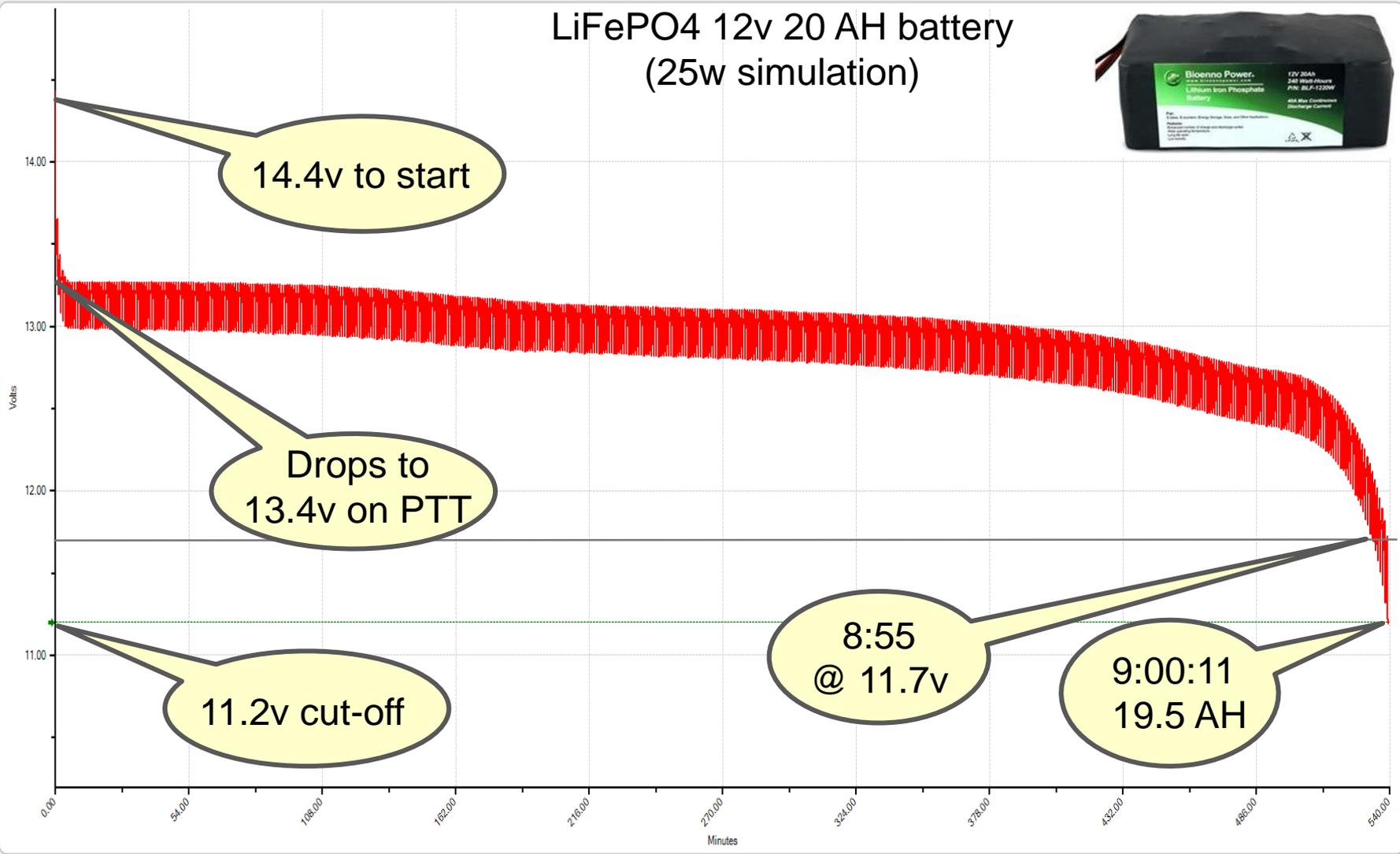
Rachel Kinoshita - KK6DAC

# 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

# 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

