



Lithium Polymer Battery Testing

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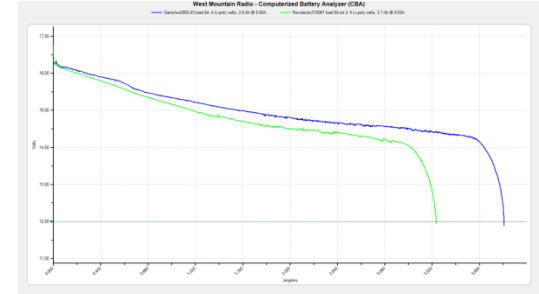
What is the best way to test your batteries?

- Dead Stick - Airplane falls out of the sky
- Flight Performance
- Visual Inspection
- Load Test
- Battery Voltage
- Equivalent Series / Internal Resistance



Battery Testing

- Best Method “Battery Load Testing”
 - Costly requires expensive equipment
 - Time consuming slow process
 - Tests how battery is actually used – real life test
- Internal or Equivalent Series Resistance (IR or ESR)
 - Quick and easy to perform
 - Requires special test equipment
 - Not repeatable results
- Battery Pack Voltage and Cell Voltage
 - Simple Fast
 - Low Cost
 - Provides NO information on capacity or performance
- Flight Performance - Crash n Burn
- Visual Inspection – Puffy battery

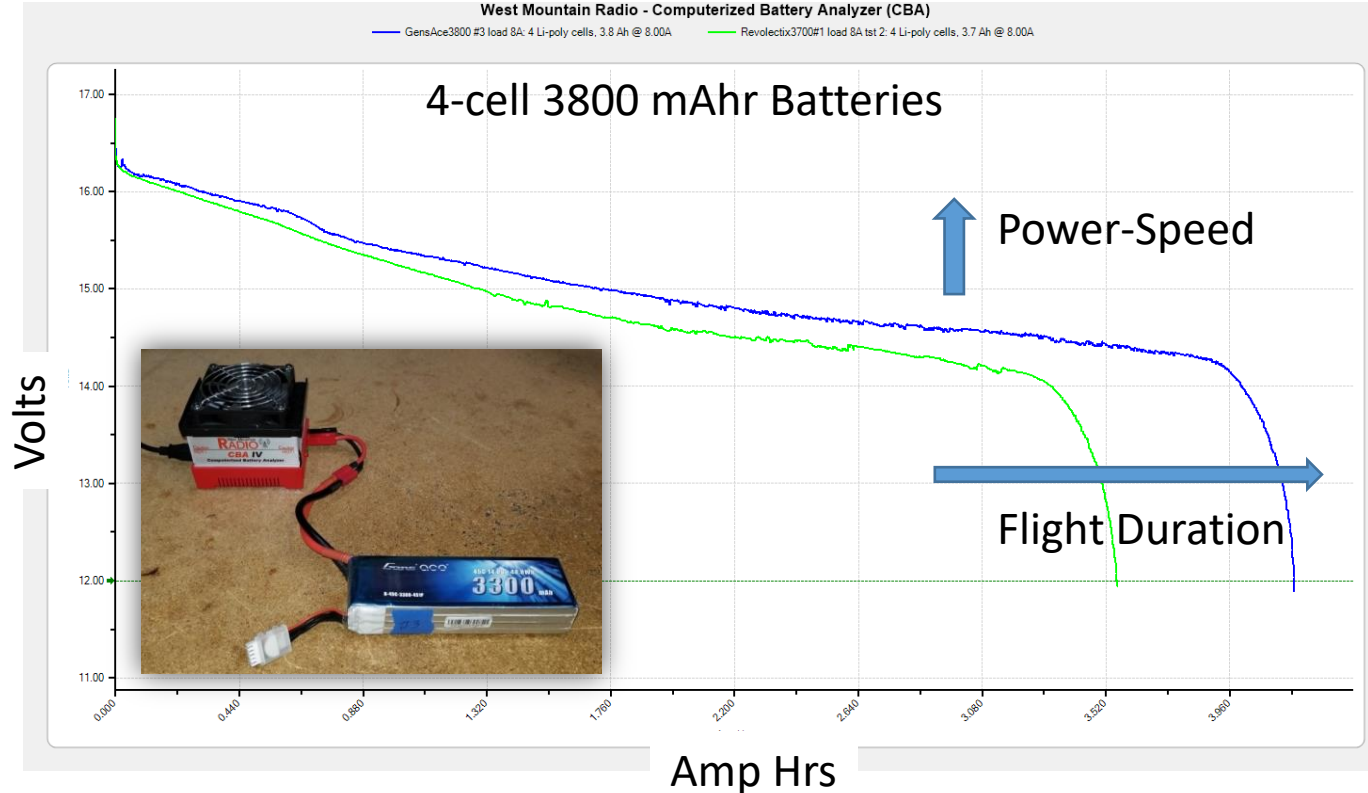




Battery Load Testing

Voltage versus Amp Hrs (Time)

Constant current load



Pros

- Measures Capacity
- Measures Voltage
- Measures Power
- Simulates Flight

Cons

Requires:

- Computer
- Software
- Battery load
- \$\$\$
- Time consuming

Battery Equivalent Series Resistance (ESR) Internal Resistance (IR)

Simple Quick measurement

- Dedicated ESR Meters
- Built into many Battery Chargers
- Manual ESR Measurement with DVM





ESR Test Concept

Typical

Battery ESR (~10mΩ- 100m Ω)

Wires Connectors (<1m Ω)

Motor/Speed Controller (0.4 Ω - 0.8 Ω)

$$ESR = \frac{V_{sw_open} - V_{sw_closed}}{I_{current}}$$

EDF Jet 6-Cell LiPo Battery Pack

~24Vdc (4v/cell)

960 Watt Motor

ESR = 30mΩ (Good)

Motor/ESC = 24v/40A = 0.6 Ω

Current = 24v/0.63Ω = 38.1 Amps

Motor: 870 Watts (~10% less power)

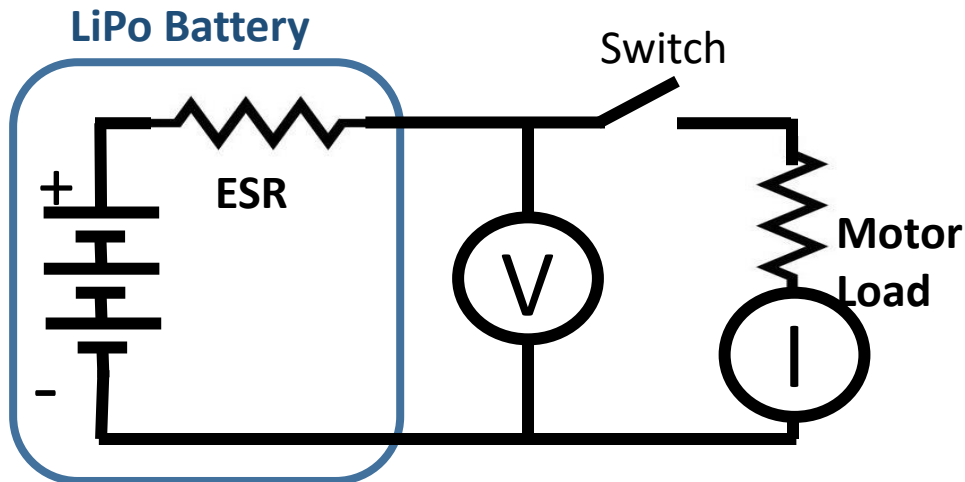
Battery ESR Heat dissipation

43.5 Watts HEAT ($P_{watts} = I^2R$)

7.2 Watts per cell

Low Resistance is Good

Heat Permanently Damages Batteries!

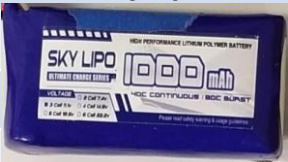


Internal Resistance Measurement

3-cell LiPo Battery 1000 mAhr

Room Temperature 71°



Battery	Cell #	ISDT T6 Lite	ESR Meter	iCharger 206B	Standard Dev
	1	37.5	34.8	46	5.8
	2	44.6	34.72	48	6.9
	3	<u>44.6</u>	<u>30.84</u>	<u>43</u>	7.5
	Total	126.7 mΩ	100.36 mΩ	137 mΩ	36.74
	1	10.0	10.52	10	0.3
	2	10.5	10.68	10	0.4
	3	<u>11.3</u>	<u>10.60</u>	<u>9</u>	1.2
	Total	31.8 mΩ	31.80 mΩ	29 mΩ	1.6
	1	69.8	34.4	45	18.2
	2	40.9	30.44	41	6.1
	3	<u>61.2</u>	<u>26.04</u>	<u>34</u>	18.4
	Total	171.9 mΩ	90.88 mΩ	120 mΩ	41.0

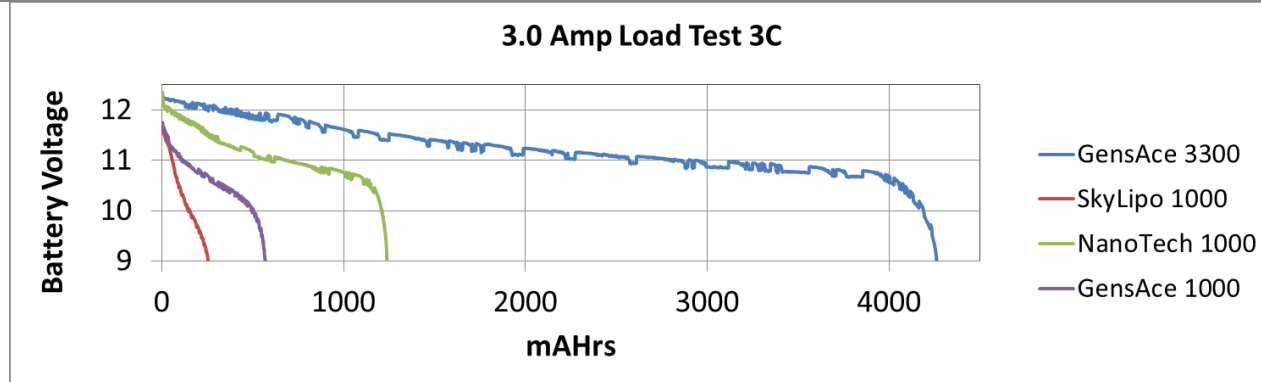
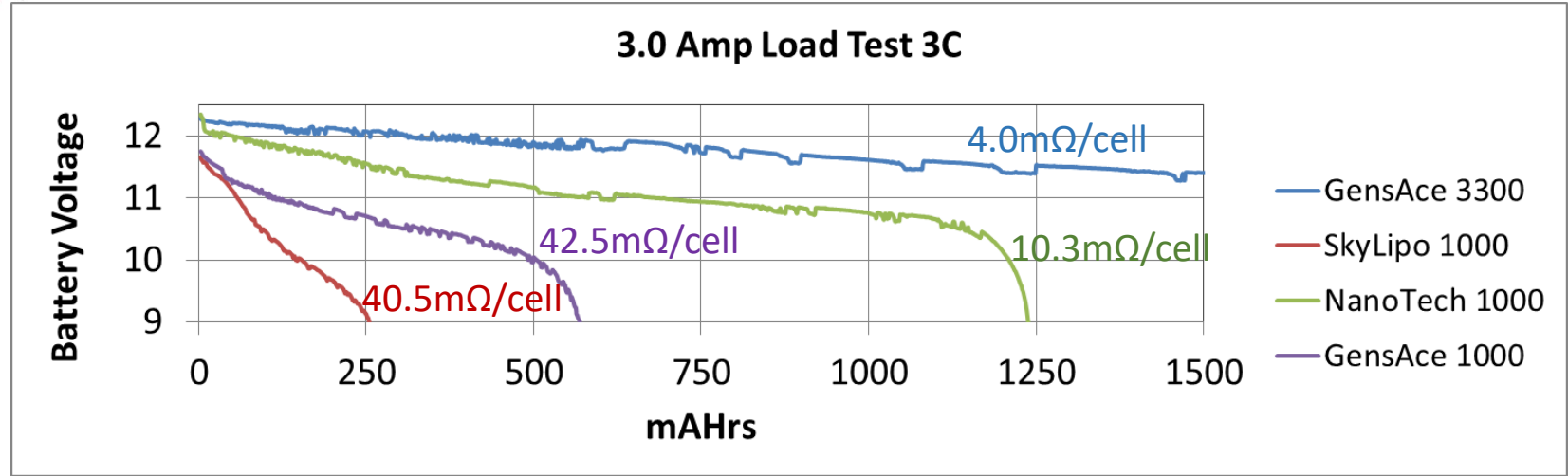
POOR

GOOD

POOR



Battery Load Tests Comparison



ESR increased 68% to 103%

~30 Deg Change

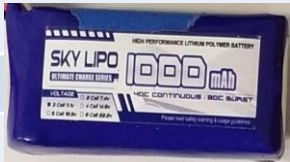
Temperature of battery is critical!

3-cell LiPo Battery 1000 mAh

ESR Measurement

Room Temperature 42°



Battery	Cell #	ISDT T6 Lite	ESR Meter	iCharger 206B
	1	-	-	85
	2	-	-	93
	3	-	100.36 mΩ	137 mΩ
	Total	-	168.6 mΩ	258 mΩ
	1	-	19.24	19
	2	-	20.48	21
	3	-	31.80 mΩ	29 mΩ
	Total	-	59.48 mΩ	59 mΩ
	1	-	-	86
	2	-	-	81
	3	-	90.88 mΩ	120 mΩ
	Total	-	152.4 mΩ	233 mΩ



More ESR/IR Measurements



Battery	Cell #	ESR Meter (mΩ)	Icharger206B (mΩ)	ISDT T6 Lite (mΩ)
#1 GensAce 3800 4-Cell 25C	1	10.72	20	19.2
	2	9.36	19	19.9
	3	8.16	17	16.9
	4	<u>6.92</u>	<u>16</u>	<u>15.5</u>
	Total	35.16	72	71.5
#2 Gens Ace 3300 mAHr 45C 3-cell	1	4.60	4	4.7
	2	4.68	4	4.7
	3	<u>4.68</u>	<u>2</u>	<u>4.5</u>
	Total	13.96	10	13.9
#3 Gens Ace 3300 mAHr 45C 4-cell	1	5.24	5	4.5
	2	5.32	5	4.9
	3	5.24	4	4.8
	4	<u>5.12</u>	<u>5</u>	<u>4.9</u>
	Total	20.92	19	19.1

ESR Measurements

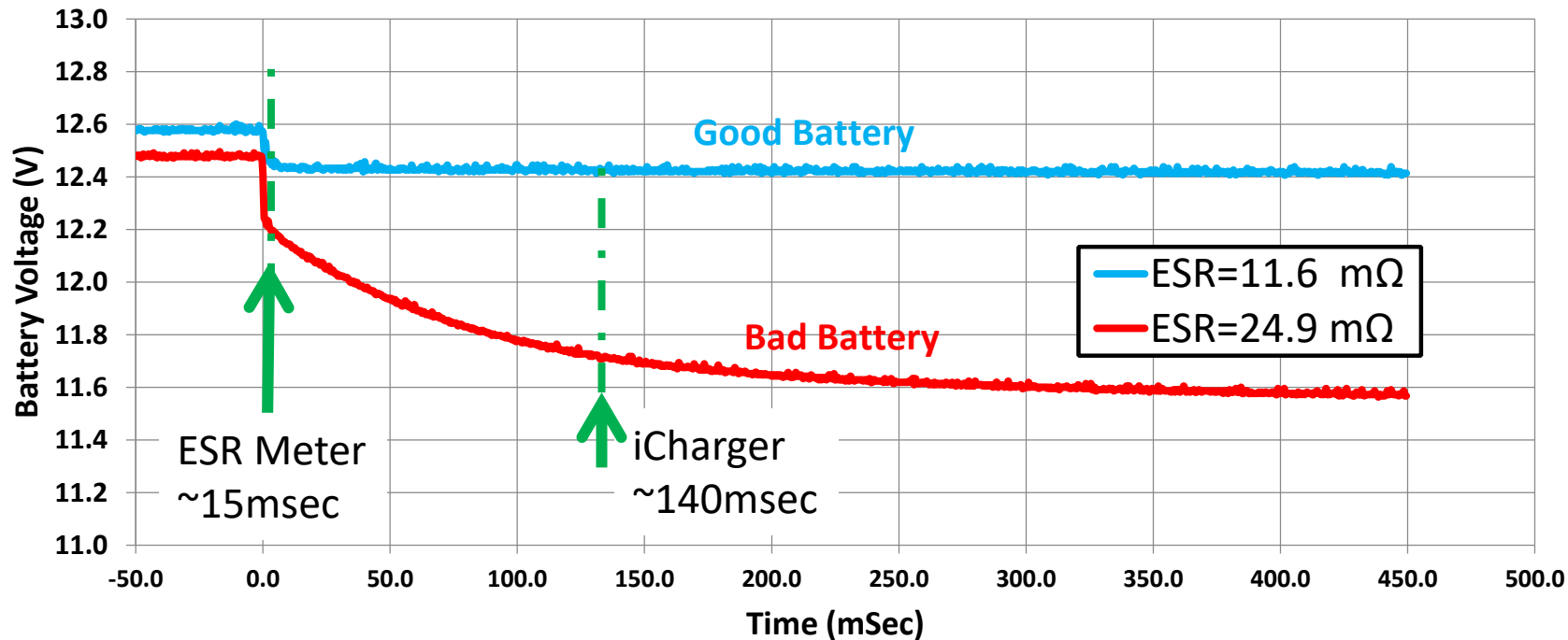


Battery	Cell #	ESR Meter (mΩ)	Icharger206B (mΩ)	ISDT T6 Lite (mΩ)
#4 Nana-Tech 1000 mAHr 3-cell	1	13.80	14	15.1
	2	15.08	16	15.5
	3	13.40	14	13.0
	4	<u>16.64</u>	<u>19</u>	<u>17.2</u>
	Total	58.92	63	60.8
#5 REVOLLECTRIX 2200 3-Cell	1	4.16	5	5.0
	2	6.48	6	6.6
	3	<u>6.04</u>	<u>4</u>	<u>6.4</u>
	Total	16.68	15	18.0



Battery Voltage vs Time

Battery Low ESR vs High ESR





Summary of ESR/IR Meters

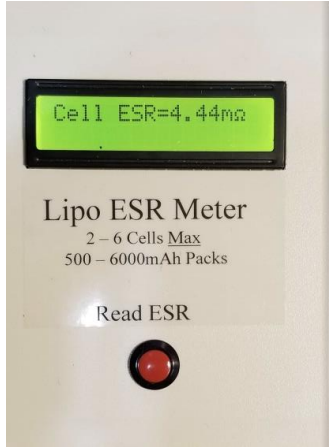
Lipo ESR Meter

Pros:

- Very repeatable measurements for low ESR batteries
- High Resolution 0.01mΩ
- Expensive only an ESR meter

Cons:

- Manually Test each cell separately
- Short test duration does not detect poor batteries



iCharger 206B

Pros:

- Repeatable measurements
- Test AOLL Cells in one step
- Multi-Function Charger/Discharger/ESR Meter

Cons:

- Only 1 mΩ resolution



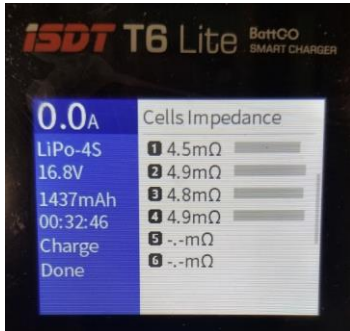
ISDT T6 Lite

Pros:

- Very repeatable measurements
- Good Resolution 0.1mΩ
- One step: Measures ESR while charging batter
- Color Display

Cons:

- Can only measure ESR during charging





Lessons Learned of ESR/ IR Measurements

Impacts of ESR/IR values

- Temperature of battery
- State of charge
- Test Load Current
- Time when measurement is taken
- Use consistent measurement approach
 - Temperature
 - Instrument
 - Battery Charge state

Why Low ESR/IR ?

- Performance
- Battery Longevity
- Safety
- Easy to Compare Batteries



Thank You for Attention

May 1, 2019

Special
Thanks
to
Larry
Fagan

