Modelling the performance of rechargeable Li-Ion batteries

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Graduate Modelling Workshop, August 8, 2016

Rechargeable Lithium Ion Batteries

- Panasonic NCR18650B batteries
- Nominal 3.6V
- Capacity 3200 mAh
- Current measured in “C”

Manufacturer Technical Specification Sheet

Panasonic

Lithium Ion

NCR18650B

Features & Benefits

- High energy density
- Long stable power and long run time
- Ideal for notebook PCs, boosters, portable devices, etc.

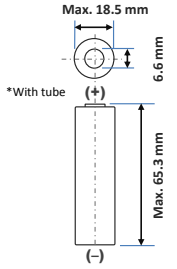
* At temperatures below 10°C, charge at a 0.25C rate.

Specifications

Rated capacity(1)	Min. 3200mAh
Capacity(2)	Min. 3250mAh Typ. 3350mAh
Nominal voltage	3.6V
Charging	CC-CV, Std. 1625mA, 4.20V, 4.0 hrs
Weight (max.)	48.5 g
Temperature	Charge*: 0 to +45°C Discharge: -20 to +60°C Storage: -20 to +50°C
Energy density(3)	Volumetric: 676 Wh/l Gravimetric: 243 Wh/kg

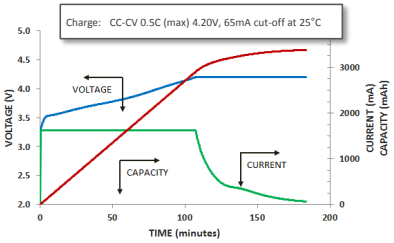
(1) At 20°C (2) At 25°C (3) Energy density based on bare cell dimensions

Dimensions

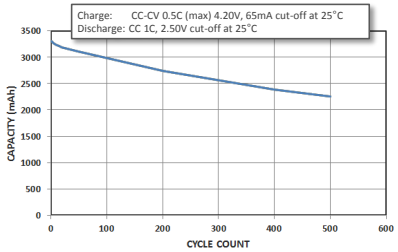


For Reference Only

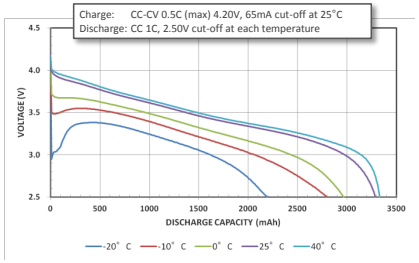
Charge Characteristics



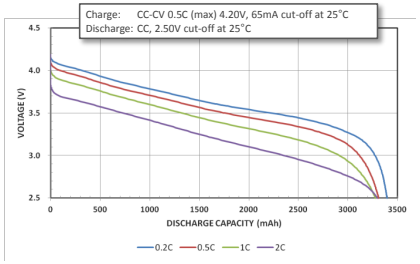
Cycle Life Characteristics



Discharge Characteristics (by temperature)



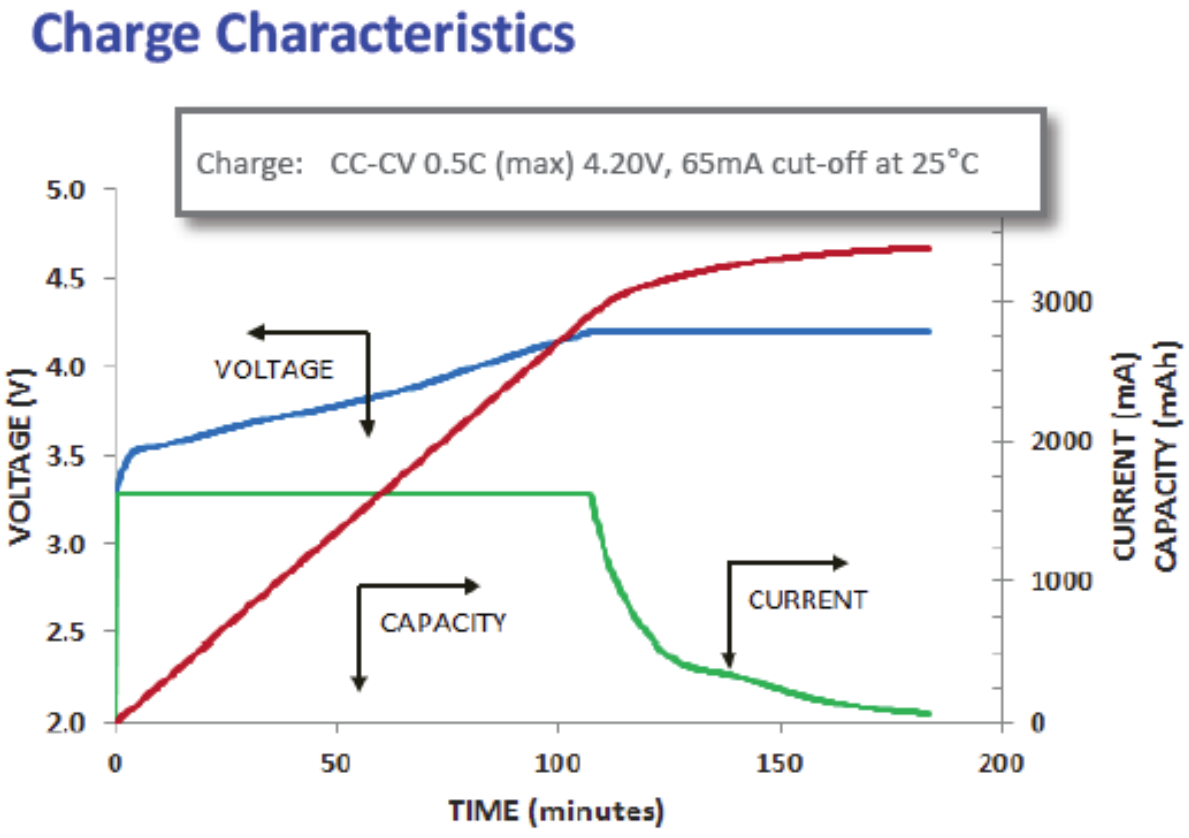
Discharge Characteristics (by rate of discharge)

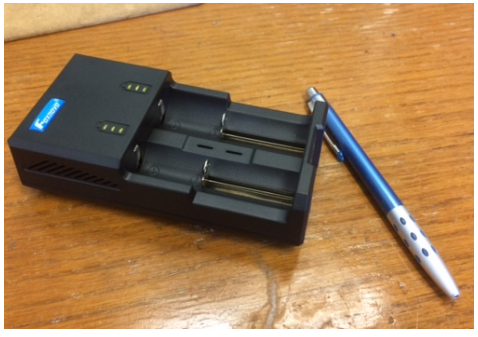


The data in this document is for descriptive purposes only and is not intended to make or imply any guarantee or warranty.

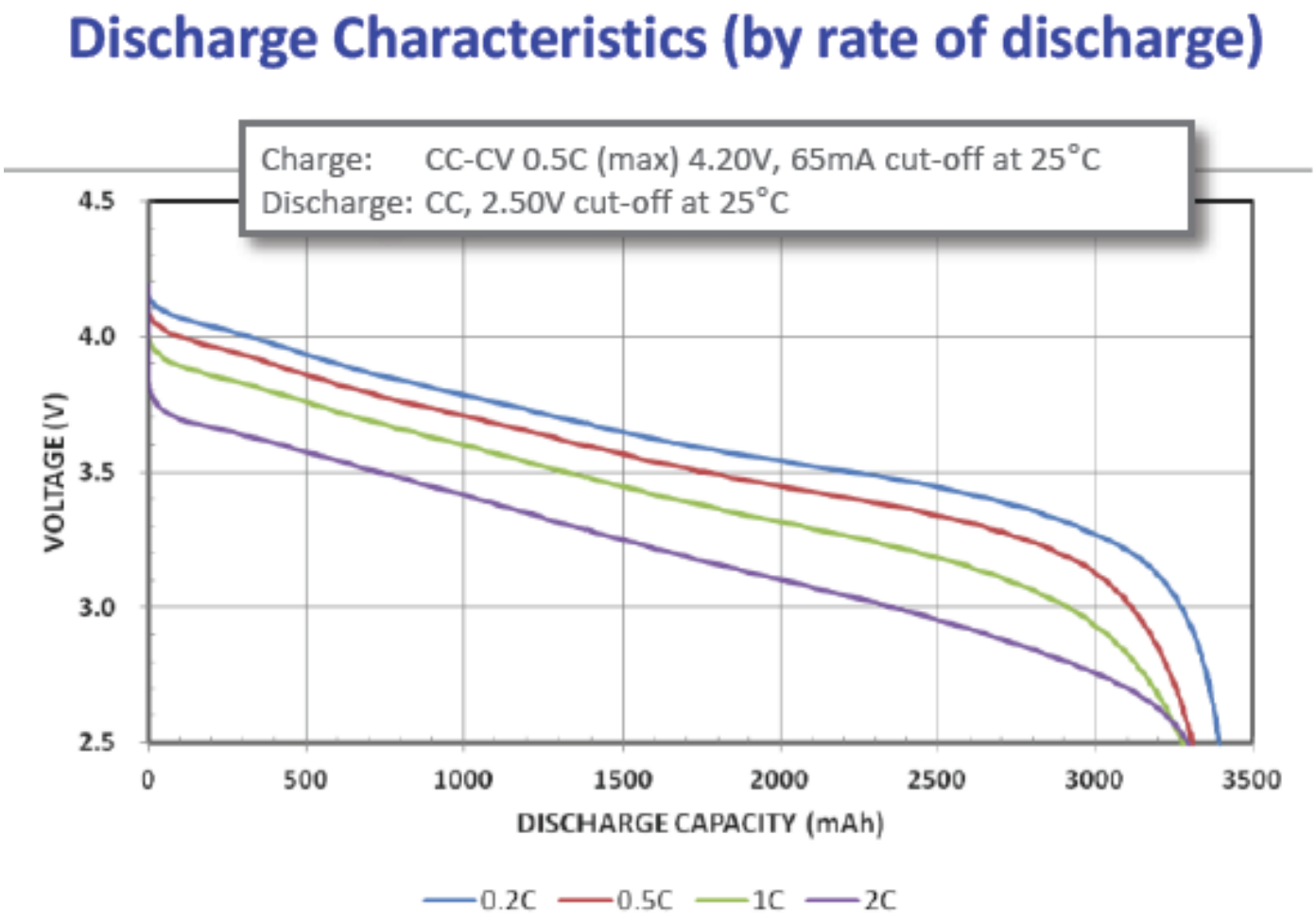
For more information on how Panasonic can assist you with your battery power solution needs, visit us at www.panasonic.com/industrial/batteries-oem, e-mail secsales@us.panasonic.com, or call (469) 362-5600.

Charging


Charge Characteristics
Charge: CC-CV 0.5C (max) 4.20V, 65mA cut-off at 25°C
VOLTAGE (V)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
VOLTAGE
CAPACITY
CURRENT
0
50
100
150
200
TIME (minutes)
3000
2000
1000
0
CURRENT (mA)
CAPACITY (mAh)



Discharging



Notice the 2.5V cutoff

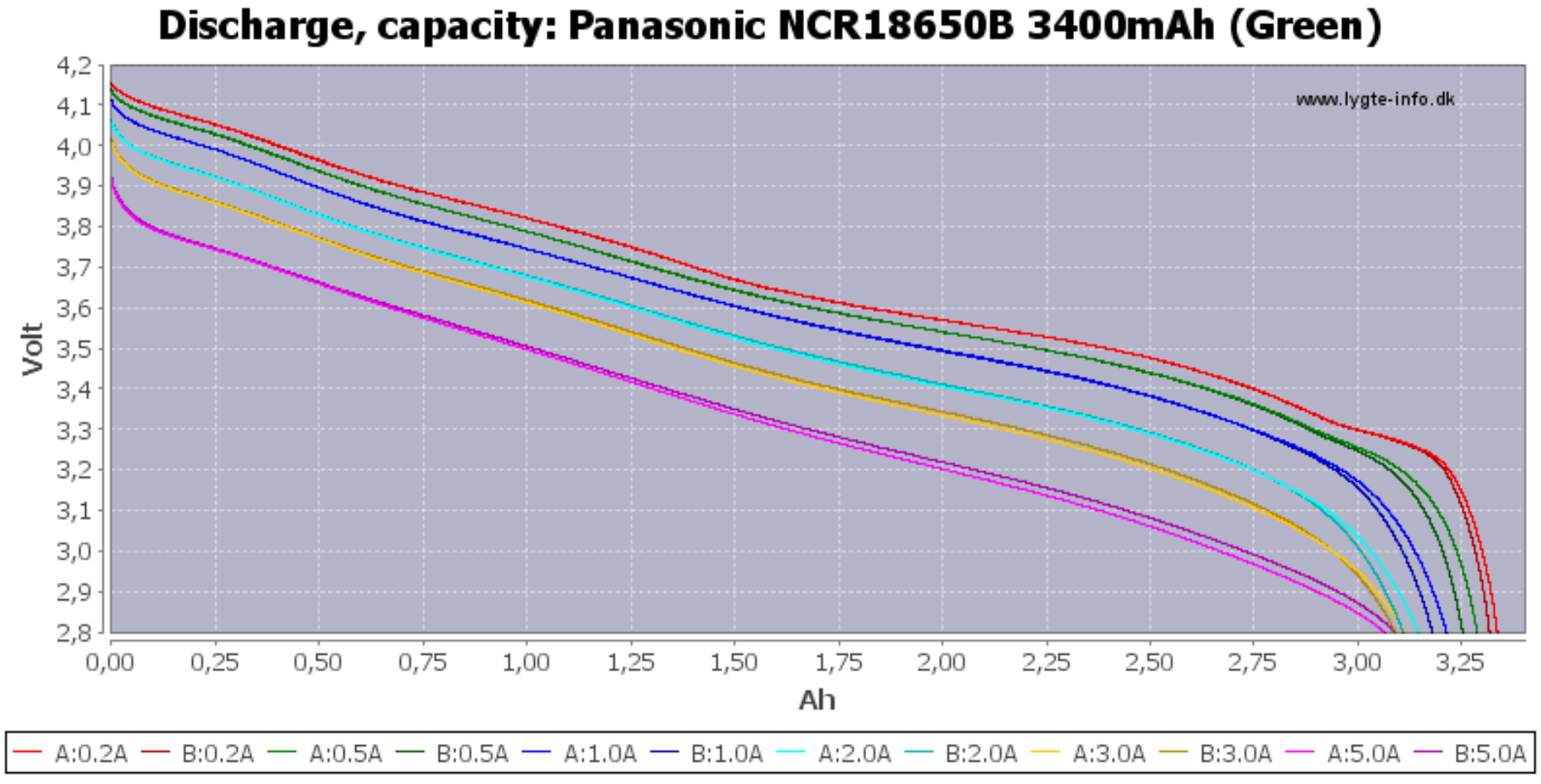
First Target: Empirical Models of Charge and Discharge

- State of Charge (SOC) and Voltage or Current (or a relationship between them) algebraically determines the rate of change in the SOC.
- First target: empirical fit to this relationship. Some extrapolation needed (example: low voltage initial charging).
- Equivalent circuit models *or* system Identification (black box fit).

Battery Packs

- 74 US18650 batteries in one brick connected in parallel (currents add).
- 96 bricks connected in series (voltages add).

Battery Differences



Second Target: Series and Parallel Arrangement

- Suitable statistics for battery variability.
- Models of batteries with different characteristics connected in series and parallel. Charging and Discharging.
- Extreme cases: failure mechanisms.
- Feedback: are "weak" batteries put under more stress when connected?
- Explain why the Tesla battery bricks are connected in parallel, not in series.

Third Target Options

- Investigate Battery Management Systems.
- Investigate performance and failure statistics in parallel versus series designs.
- Stack level thermal modelling?
- Open the hood: look at more detailed electrochemical models. Specifically, “quasi-2D” models in which one dimension is in the electrode thickness and the other is local grain depth.

Experiments

- Dr. Arman Bonakdarpour in Chemical Engineering has agreed to contribute his expertise.
- Battery Science lecture 3:00-4:30 in CHBE 304.
- Afterwards, he'll take us to his group's battery lab to start some charge/discharge experiments.
- Tuesday afternoon at 2:00 experiments can continue.
- You can design experiments to fill in holes in the data used for the empirical fit in the First Target work.
- If you want to investigate something experimentally, you can try and convince Arman that it is interesting.