National Aeronautics and Space Administration

MATLAB Based Algorithm to Find the REMAINING STATE OF CHARGE for Li-ion Batteries

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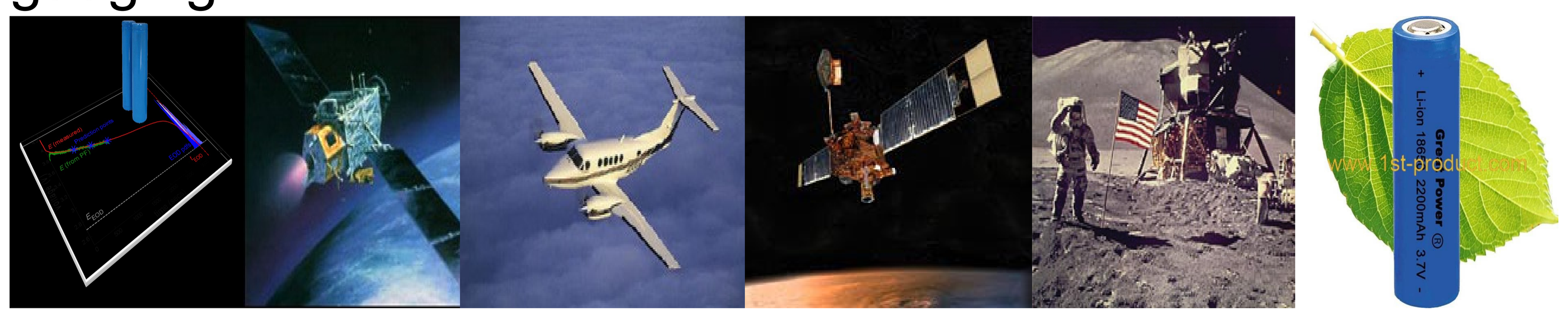
Introduction

Li-ion batteries are the main component of many machines. It is critical to the well being of the overall system. To maintain the health and estimate remaining state of charge (RSOC)of the battery four applications need to be taken care of: charge control, protection, authentication, and fuel gauging.



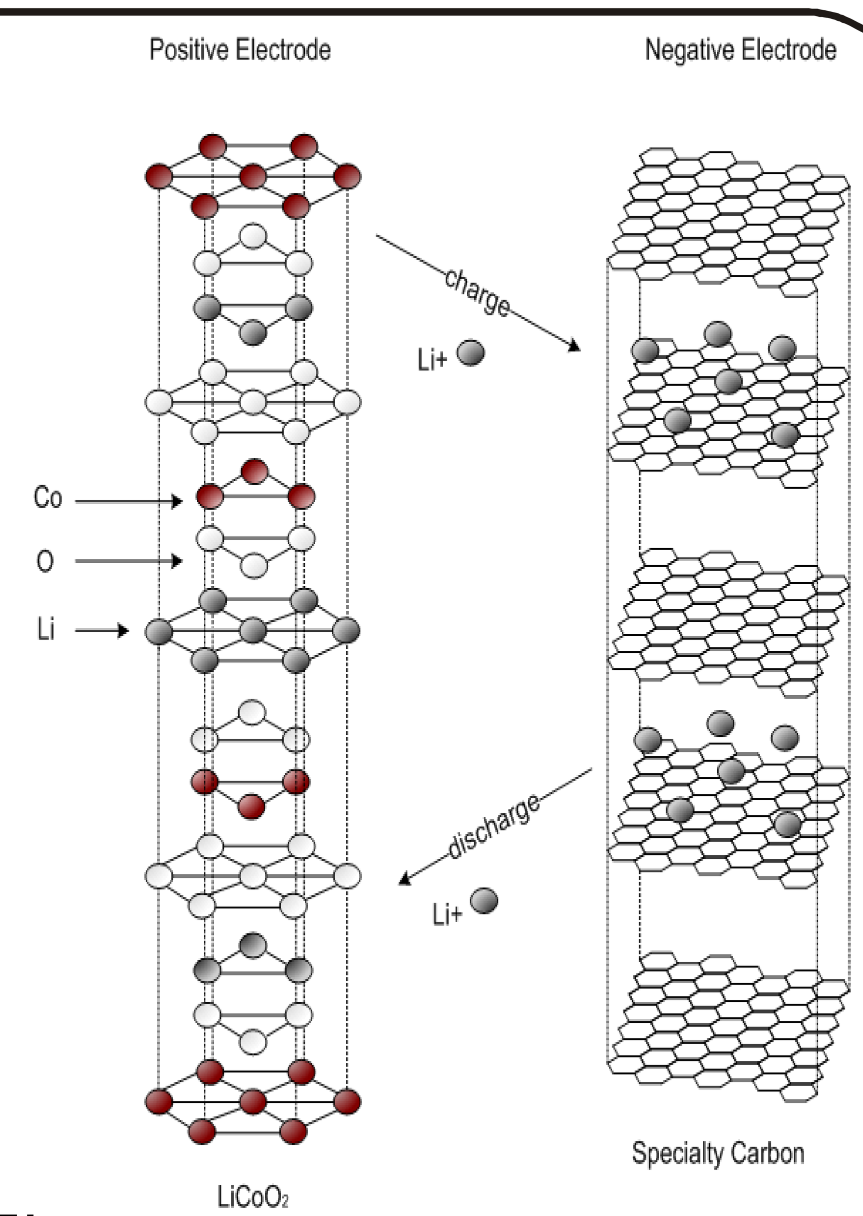
- •Charge control provides power conversion and controls charges.
- •Li-ion cell resides in battery pack to protect from different conditions.
- •Authenticate or validate the battery attached to host system.
- •Fuel gauge function tracks the remaining state of charge(RSOC).

Li-ion Batteries

Li-Ion cell has a three layer structure. A positive electrode plate, a negative electrode plate and a separator layer.

Lithium battery uses lithium cobalt oxide as positive electrode - cathode

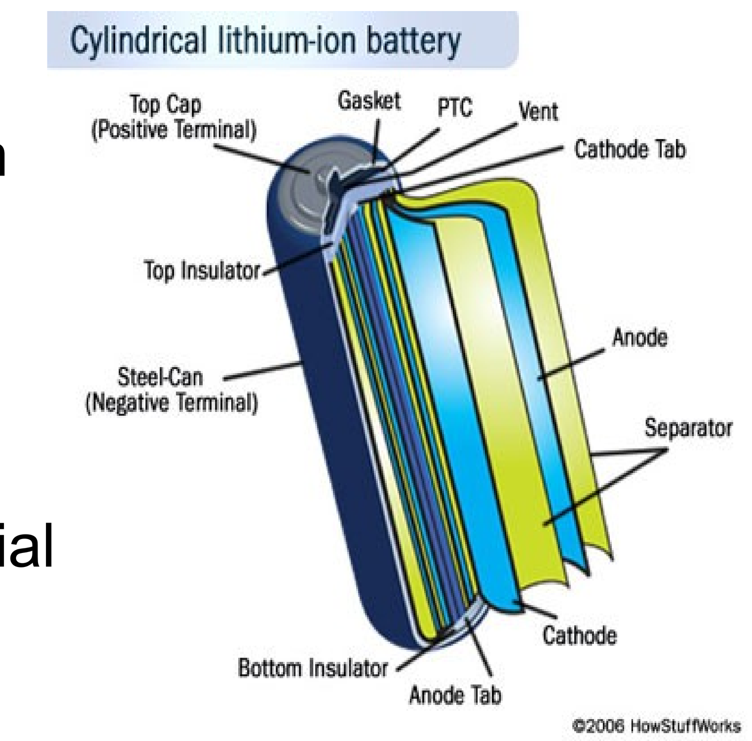
A high crystallized special carbon as negative electrode - anode.



$$LiCoO_2 + C_6 \underset{discharge}{\overset{charge}{\rightleftharpoons}} Li_{1-x}CoO_2 + C_6Li_x$$

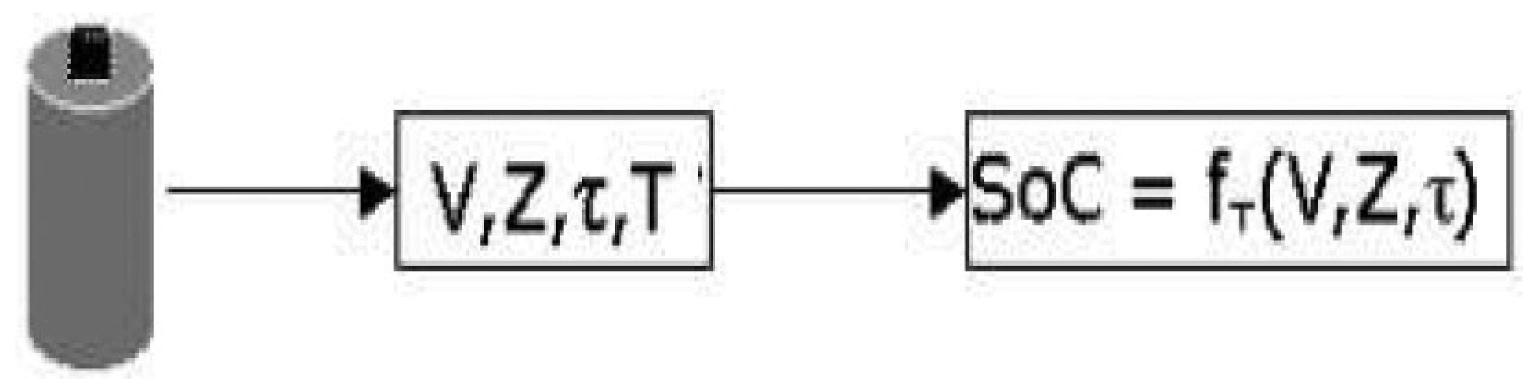
Goal

- •Implement in MATLAB the battery prognostics algorithm as described in "Impedance Track Based Fuel Gauging."
- •Validate the algorithm using the battery testbed.
- •Edit the battery prognostics website to present the material in a more educationally accessible format.

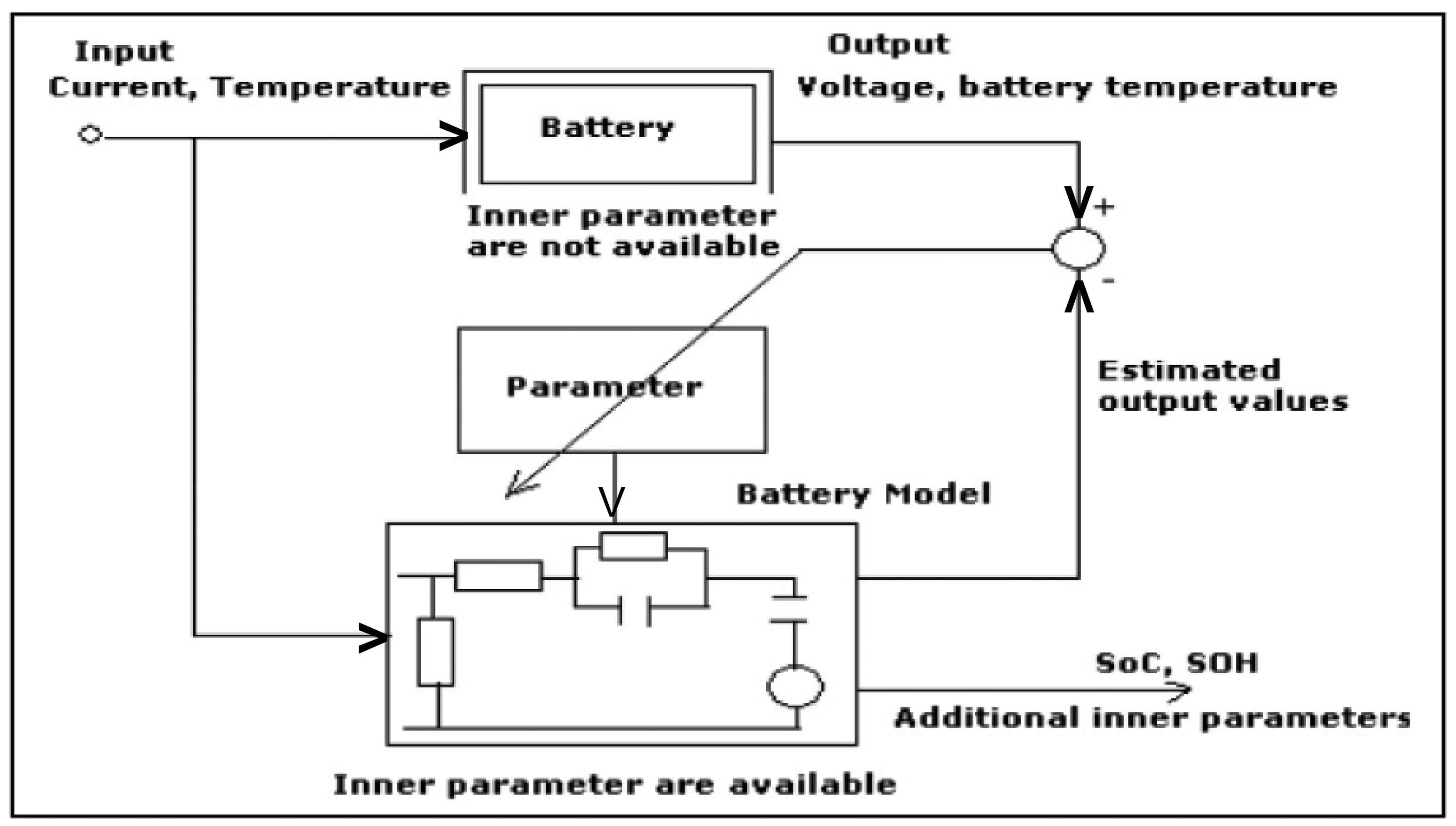


Experimentation

The RSOC of the battery can be determined from direct measurements. Most relations between battery variables and the SoC depends on the temperature (T).



Where SoC is state of charge,and the variables such as battery voltage (V), battery impedance (Z), and the voltage relaxation time (τ)



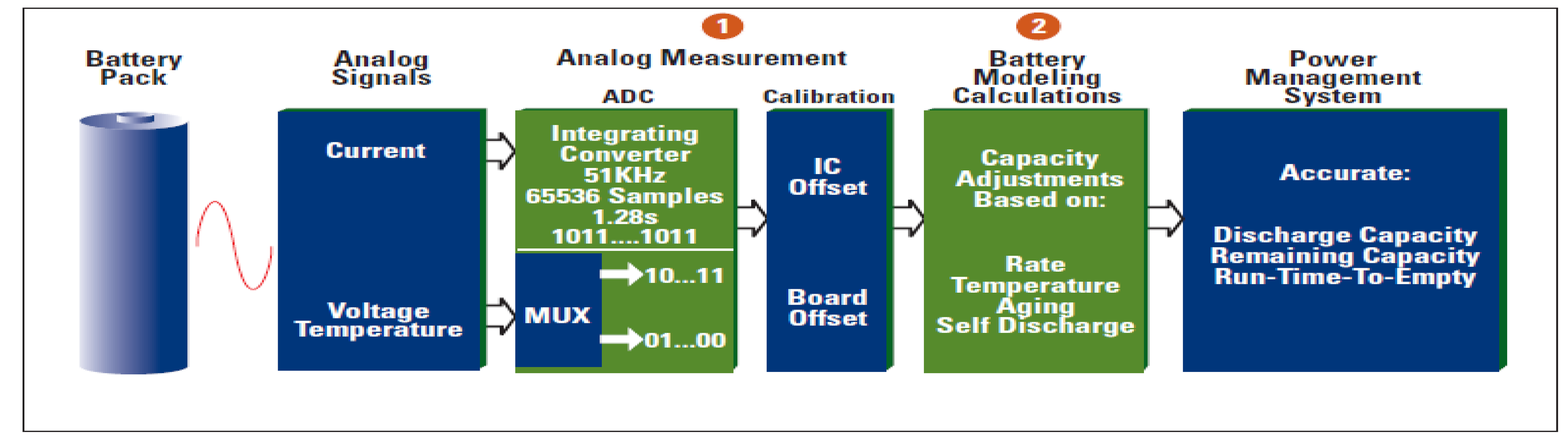
RSOC determination using Kalman filter.

This method of fuel gauge not only accurately gauges the battery but control the charge and authenticates the battery pack.

Battery Fuel Gauge

The basic parameters used for battery fuel

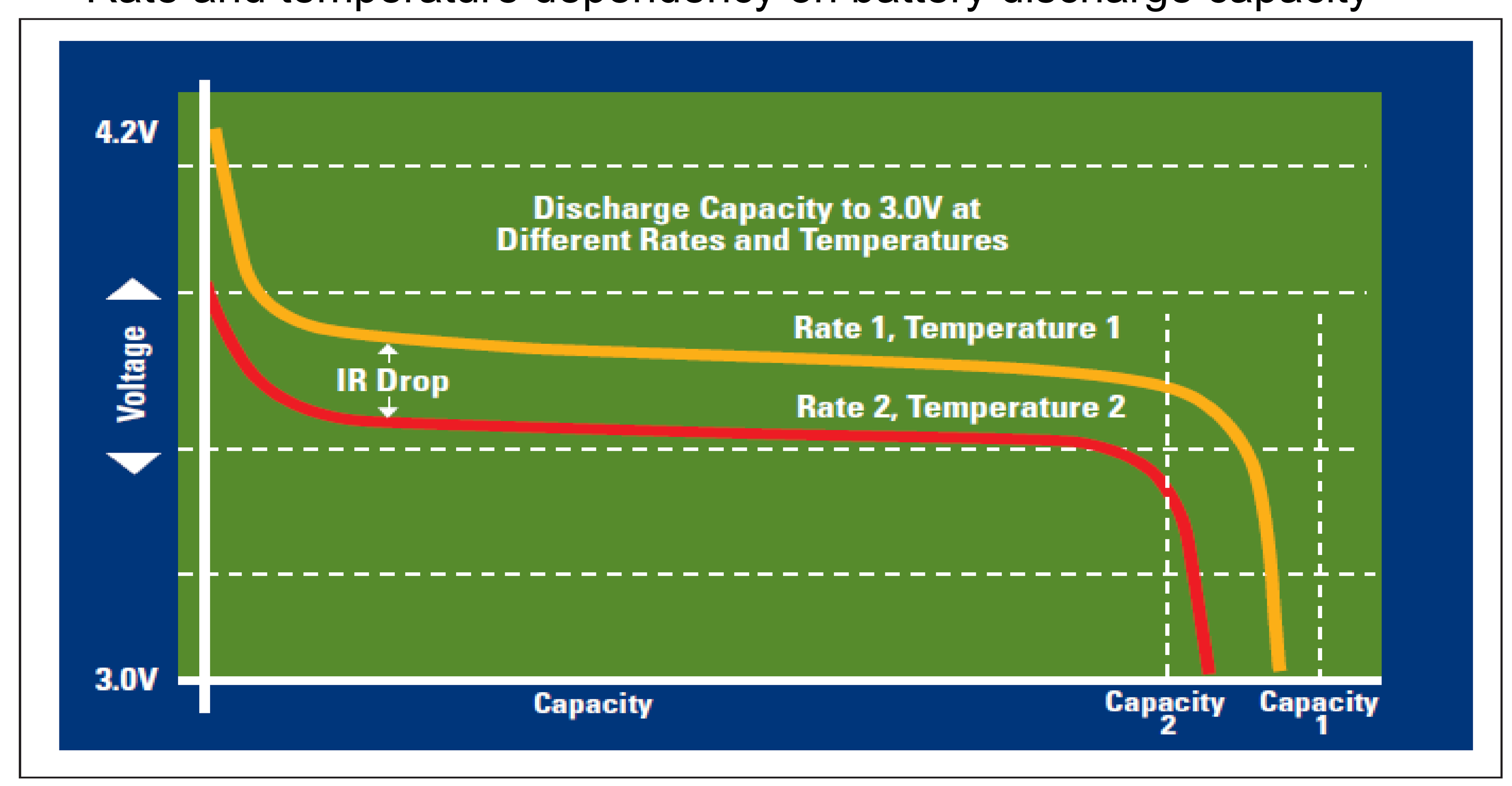
Reported information from battery fuel gauge	*Description*
Voltage (V)	Battery pack voltage (V)
Temperature (T)	Battery pack temperature (K)
Current (C)	Instantaneous charge or discharge current (mA)
Average current (AC)	Average current over 20-30s (mA)
Remaining capacity (RM)	Remaining capacity of the battery (mAh), i.e., the amount of fuel that is left in the "tank" RM=RSOC*FCC
Full-charge capacity (FCC)	Discharge capacity of the battery (mAh), i.e., the size of the "tank"
Remaining state of charge (RSOC)	Percent full, RSOC=RM/FCC
Run-time-to-empty (RTTE)	The amount of time (minutes) until the battery is empty, RTTE=RM/AC



The two components of battery fuel gauge accuracy depend on analog measurement and battery modeling.

Result

Rate and temperature dependency on battery discharge capacity



The RSOC of batteries will help make quick decisions using battery fuel gauge and Kalman filter in MATLAB algorithms.

Acknowledgment & References

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