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Modeling Energy Storage Systems for Energy Surety in Forward Operating Bases

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Exceptional service in the national interest

Sandia National Laboratories

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Objective: Model and compare energy storage systems used to improve microgrid efficiency and energy surety.

Abstract:

- In times of war fuel is a vital resource that can be very costly and dangerous to obtain. To address this issue Sandia National Laboratories, the Department of Energy and Base Camp Integration Laboratory (BCIL) have partnered to improve the efficiency of Forward Operating Bases (FOBs) to save money and lives.
- Five energy storage systems are being evaluated by Sandia for performance on a FOB micro grid. Some of these systems will go on to be tested on the BCIL test FOB
- Each system is being modeled in MATLAB to compare effectiveness at improving energy surety for both military and civilian microgrids.

Background:

When in the field the military use FOBs to conduct missions away from the Main Operating Base (MOB). Tactical Quiet Generators (TQG) are used to supply these bases with power. Transporting fuel for these generators by convoy is costly in both lives and money. To save fuel and prevent these losses Base Camp Integration Laboratories (BCIL) conduct energy efficiency experiments for the FOBs. Their work includes testing TQGs in a microgrid which can increase fuel efficiency by 20%-30% over current levels. Additionally BCIL has begun working with Sandia National Laboratories and the Department of Energy to incorporate energy storage systems into the grid for higher efficiencies. Experimental and simulations tests have already been performed with signs of promise. The goal now is to improve upon the accuracy of this work.


2/5 Energy Storage Systems Under Test at Sandia (Rose, 2013)

Methods:

- Research methods for simulating batteries and energy storage systems
- Use test data to model a set of five energy storage systems
- Compare and test models against each other

Fort Devens Base Camp Integration Lab (Tuten, 2011)

Results So-Far:

This work looks at two methods for building a Li-ion battery model. These methods take values, which can be read off the battery spec sheet and measured with electrical metering, and estimate the battery's State-of-Charge (SOC) or voltage.

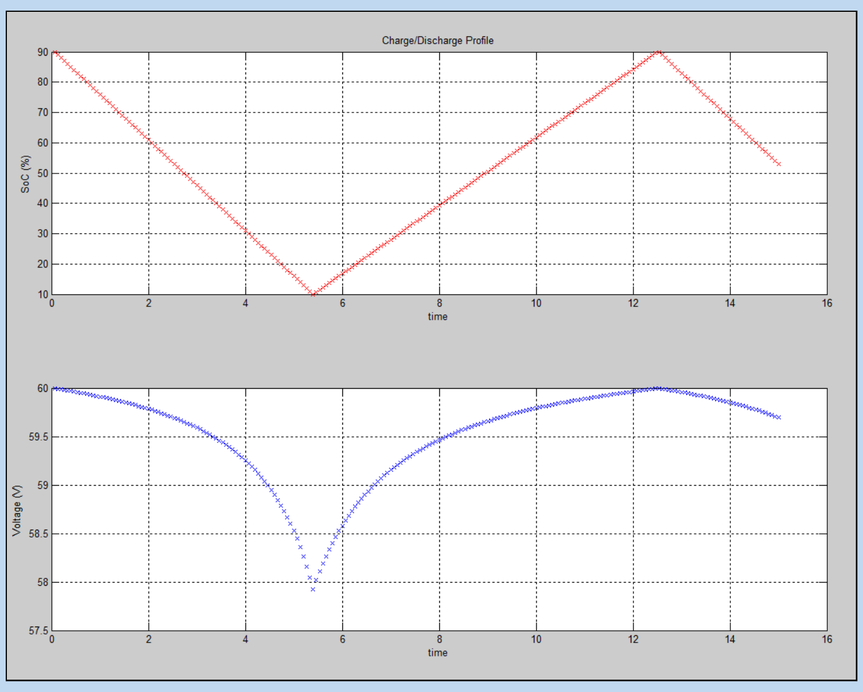
- *Method 1, Coulomb Counting*: takes account the battery's maximum capacity (Ah) and compares it to the estimated remaining capacity. This ratio is then related to SOC.

$$X = C_r/C_t$$

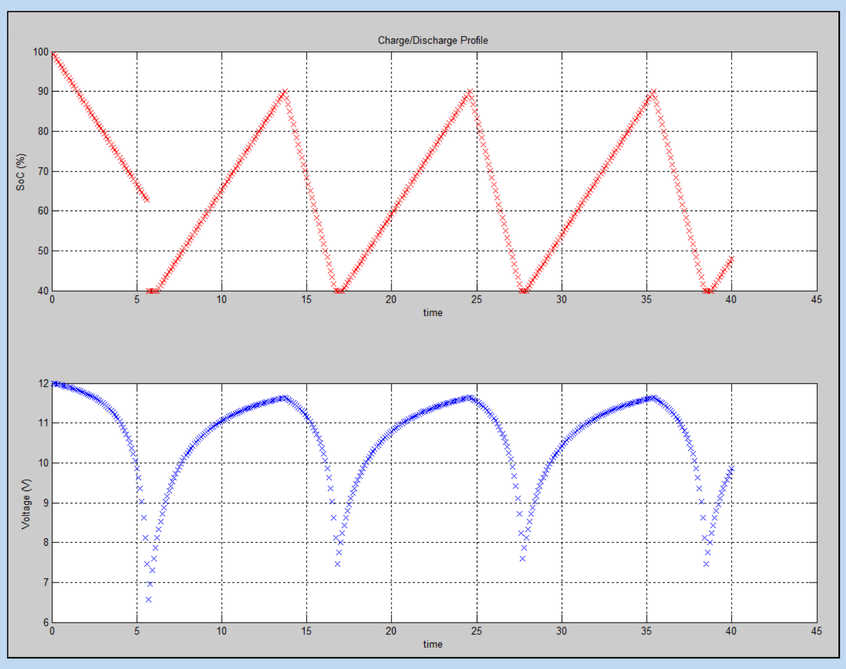
$$SOC = SOC_o \pm X$$

- *Method 2, Volt Counting*: Similar to Coulomb Counting Volt Counting takes the ratio between full capacity and remaining capacity and then relates this into the ratio between max and remaining voltage.

To the right is a single Charge /Discharge profile (cycle) generated from using generic battery inputs for Voltage and State-of-Charge outputs.



To the left is a series of cycles with a different set of input parameters to help determine accuracy of the simulation over time.



Discussion:

The research has yielded two good methods for modeling a Li-Ion battery, specifically focusing on its voltage and State-of-Charge simulations. The next step is to evaluate these methods by comparing their accuracy to collected data. The models developed by this work will expedite the application of energy storage into FOBs.

- This project meets energy surety goals by enabling battery systems to reduce the number of convoys need to resupply FOBs thereby making the supply of energy: safer, more secure, cheaper, more sustainable, and more reliable.

Energy Surety:

Safety: "Supply safe supply of energy to end user"

Security: "Protection of energy supply infrastructure"

Cost effectiveness: "Provided at affordable cost"

Sustainability: "Can be maintained for long durations"

Reliability: "Can provide energy when and where needed"

Future Work:

- Use test data to model a set of five energy storage systems
- Compare and test models against each other

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