Interreg Sudoe

EUROPEAN UNION

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Research and innovation

Electrical equivalent lithium cell model considering the effect of temperature

Authors and university: Sara VEGA-MARTINEZ, University of Montpellier

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APPLICABLE AND REFERENCE DOCUMENTS

List of all references used or mentioned in the main text, and may include a list of the acronyms used in the report. A change record table, like the one reported below, should be added in this section.

TABLE 1: Change log record table

Edition/Revision	Date	Description of the change
V0.0.1	18/12/2019	Initial version of the document

INTRODUCTION

For preparation to successfully a space mission, it is essential to study the power budget of the satellite for different mission scenarios. For that, it is necessary to model the consumption of the spacecraft, the electrical power system (EPS), the solar panels, and the batteries. Batteries are used for the storage of satellite energy, and their behaviour influences the study of the different situations of a mission. Therefore, there is a growing need for an accurate model of batteries. Figure 1 shows a battery equivalent circuit model, which is composed of one voltage source, one series resistor, and several RC blocks. Those RC blocks simulate the dynamic behaviour of the batteries.

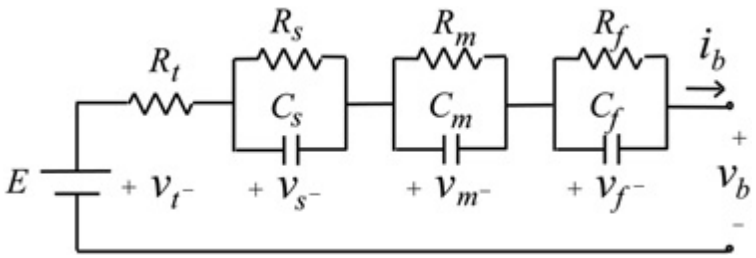

FIGURE 1. BATTERY EQUIVALENT CIRCUIT MODEL [1]

The temperature is an important parameter when modelling batteries. The satellite can work in a temperature range of -20°C to 90°C during a mission. The battery models must account for thermal effects because of the paramount importance of temperature in kinetic and transport phenomena of electrochemical systems [2].

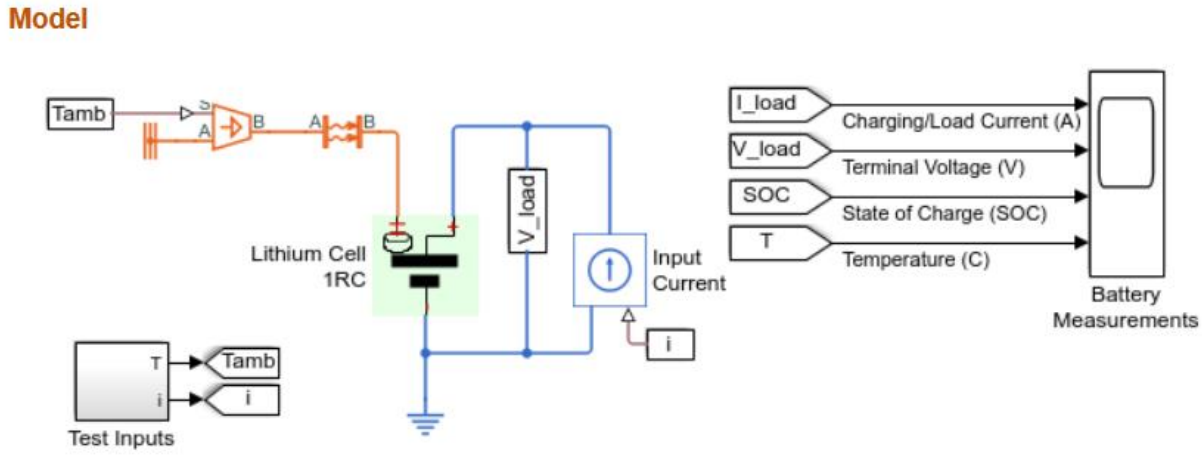

FIGURE 2. LITHIUM BATTERY CELL - ONE RC- BRANCH EQUIVALENT CIRCUIT [3]

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In the literature, there are different mathematical models of battery and different methodologies to calculate them. For example, figure 2 shows a Matlab model. This example shows how to model a lithium cell using the Simscape™ language to implement the elements of an equivalent circuit model with one RC branch. A simple thermal model is used to model battery temperature. It is assumed that cooling is primarily via convection, and that heating is primarily from internal resistance [3].

The model parameters vary depending on the battery, and there are several methodologies for calculating these parameters. For example, electric circuit modelling for lithium-ion batteries by intermittent discharging [1]. This study introduces a battery modelling technique for lithium-ion batteries. Repeated intermittent discharging experiments are performed on batteries for a lot of times, and followed by analyses on the battery terminal voltage curves to find an appropriate battery model based on circuit elements and the equations of the battery model parameters.

STATE-OF-THE-ART

This challenge aims are to develop the knowledge of the students of the NanoStar programme on the modelling of batteries for the power budget of nanosatellite and the attitude of the batteries into the space environment. It is proposed by the University Space Center of Montpellier (CSUM).

CENTRE SPATIAL UNIVERSITAIRE DE MONTPELLIER

CSUM is an educational platform of Montpellier University for Science and Technology through nanosatellite engineering.

In France, the CSUM is one of the leaders in the development of student nanosatellites. It is also a European center of reference devoted to bring together equipment and skills for the development, production, testing and operation of nanosatellites. These projects involve student interns and encourage regional economic development.

To do this, the CSUM has facilities and equipment dedicated to nanosatellite engineering:

- A control center including a transceiver radio station and antennas in UHF and S-Band;
- A dedicated CIC room (concurrent engineering center);
- AIT facilities (Assembly, Integration and Testing) including a clean room and multiple workshops;

The CSUM develops its own nanosatellite technology producing 1U and 3U CubeSats with the support of the Van Allen Foundation that subsidizes the EPS (Electrical Power System) engineer.

SPECIFIC CHALLENGE OBJECTIVES

The challenge is to develop a real temperature lithium cell model with thermal dependence. To perform the challenge, the student will have to develop the following actions:

1- Report about different lithium battery models and methodologies to calculate the model parameters.
2- Preparation of the testbench to calculate the lithium cell model parameters.
3- Battery tests to calculate the parameters of the mathematical model.
4- Calculation of the battery model.
5- Validation of the mathematical model with the real batteries.

Duration of the challenge: 4 months

Deliverables: A report, in English, describing the activities carried out, the original goals and the achieved ones, with the NanoStar Template and a presentation of the challenge.

Composition of the team: One or more students from the Universities of the NanoStar project. If possible as much women as men and from different countries.

Rewards: A diploma of participation, a visit and goodies from the University Space Center of Montpellier (CSUM), the University of Montpellier (UM) and NanoStar project and others rewards for the most innovative team.

If you are interested in this challenge, contact us at nanostar-projet@umontpellier.fr or on the NanoStar website.

USEFUL SOURCES

[1] Y. Hsieh, T. Lin, R. Chen and H. Lin, "Electric circuit modelling for lithium-ion batteries by intermittent discharging," in IET Power Electronics, vol. 7, no. 10, pp. 2672-2677, 10 2014. doi: 10.1049/iet-pel.2013.0787.

[2] T. Huria, M. Ceraolo, J. Gazzarri, R. Jackey. "High Fidelity Electrical Model with Thermal Dependence for Characterization and Simulation of High-Power Lithium Battery Cells," IEEE International Electric Vehicle Conference, March 2012.

[3] Lithium Battery Cell - One RC-Branch Equivalent Circuit. https://www.mathworks.com/help/physmod/simscape/examples/lithium-battery-cell-one-rc-branch-equivalent-circuit.html.