Simulink Model of NPSAT1 Power System
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Introduction

NPSAT1 is a low-cost, technology demonstration satellite hosting a number of experiments. Commercial, off-the-shelf (COTS)-based technology will be implemented with custom designs to offer a low-cost command and data handling (C&DH) subsystem building on commercial, desktop PC architecture and standards-based specifications. In addition to an experimental C&DH subsystem, NPSAT1 will demonstrate the use of non-volatile ferroelectric RAM which is inherently radiation-tolerant and lithium-ion polymer batteries, state-of-the-art technology that will be employed offering high energy density (Watt-hr/kg) for space applications.

Experiments on-board NPSAT1 include two Naval Research Laboratory (NRL) payloads. The coherent electromagnetic radio tomography (CERTO) experiment and a Langmuir probe. The CERTO experiment is a radio beacon which, in concert with ground station receivers, is used to measure total-electron-content (TEC) in the ionosphere. The Langmuir probe will augment CERTO data by providing on-orbit measurements. The other experiments are of NPS origin. These include a novel design for a spacecraft computer board, a COTS visual imager (VISIM), and some micro-electromechanical systems (MEMS)-based rate sensors.

Description of Thesis Topic

NPSAT1's variety of experiments but limited power necessitates that on orbit experiment operations be scheduled carefully to maintain battery charge state. To do so requires consideration of the following. Orbit parameters change continuously, varying the amount of power generated over a one year period of time. Experiments may be operated in various modes with each mode requiring different amounts of power, and because the power system is a battery dominated design, the battery charge state will affect the efficiency at which power is generated by the solar panels.

In the past spread sheets have been used to estimate operations and gauge battery charge state over a one week period. This method did not model the battery or solar panels accurately and to input information for experiment operation is too cumbersome and would not suffice for daily satellite operations.

A more useful tool would be a Simulink model of the power system to include the solar panels, battery and power distribution switches, NPSAT1 subsystems and experiments. With such a tool operations could be scheduled weeks into the future. This Simulink model must include an easy method to input orbit parameters, experiment operational modes and duty cycle information, and then output state of charge for the battery.

The Simulink power system can be broken into the following blocks

1. A Simulink model of the Sony US18650 Li-ion cell (A mathematical model is available).
2. Model of solar panel power generation from data generated by on orbit propagation tool, Satellite Toolkit (STK), and solar panel specifications.
3. A block to Model losses due to battery and solar panel operating point mismatches.
4. Interface for inputting power dissipation, power modes and duty cycling for all satellite subsystems and experiments
5. Output block for telemetry points of interest.

Proposed Outline

- NPSAT1 introduction
- Overview of power system components
- Battery model description and Simulink implementation
- Solar panel model description and Simulink implementation
- Simulink implementation of remainder of model
- Tests of implementation
- Conclusions & recommendations