IAF SPACE POWER SYMPOSIUM (C3)
Advanced Space Power Technologies (3)

Author: Mr. Sven O. Schmidt
German Aerospace Center (DLR), Germany, sven.schmidt@dlr.de

Prof. Andre Thess
DLR German Aerospace Center, University of Stuttgart, Germany, andre.thess@dlr.de

INNOVATIVE COTS SPACECRAFT BATTERY DESIGN

Abstract

Novel electrical concepts and the usage of electro-chemical models allow maximizing the utilization of COTS battery cells and usage of automotive parts while reducing the overall mass and cost of the battery system. As a result means for designing a battery for either high cycle life or high utilization of energy content are available. This paper discusses a model-based system design approach for determining the effect of the mission operation on cell aging for the selected battery system.
Introducing active elements and applying electro-chemical models for spacecraft battery system design is a novel approach in space engineering. The primary scientific target was identifying battery chemistry independent system design approaches, for decreasing the overall battery mass, which is especially of interest for small spacecraft, and providing new methods for decreasing the development time and cost for a spacecraft battery.
For implementing the proposed novelty features the typically required CC/CV charger for a modern Li-Ion battery was replaced by a bi-directional active voltage adaptation with current limiter. This concept allows for an increase in utilization of the battery energy content. By doing so, the actual voltage level of the battery cells can be varied within a wide range, enabling the operation of battery cells within different regimes of cell aging. The application of electro-chemical models provides means for determining the aging of any battery cell by means of a reduced set of testing at certain conditions, which are highly satellite mission depending. As a result estimation can be provided for a range of COTS battery cells, based on limited testing effort, on how each possible COTS battery cell can actually be used within a spacecraft battery.
This paper does outline the system engineering efforts to actually design a spacecraft battery as on-board experiment for a small satellite based on this novel approach. The overall design was performed using automotive components for short mission durations and considering the replacement with rad-tolerant or rad-hard parts for longer mission duration or mission profiles with higher radiation requirements.
Test results of the cell cycling and the satellite system testing will be presented and discussed.
With the design approaches and the electro-chemical modelling discussed in this paper a flexible way for designing spacecraft batteries, independently from its actual cell chemistry, is available. With that we presented an important milestone for designing cost efficient, lightweight and modern spacecraft battery systems.