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21st IAA SYMPOSIUM ON BUILDING BLOCKS FOR FUTURE SPACE EXPLORATION AND DEVELOPMENT (D3)
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DIGITAL TWIN OF A SATELLITE BATTERY SYSTEM

Abstract

A reliable power supply of a satellite is one of the most important components of a successful mission. The power supply is usually carried out by a combination of solar panels and lithium-ion batteries. At Lower Earth Orbits (LEO), the batteries are charged and discharged approximately every 90 minutes, while experiencing various current loads and temperature changes. These processes create a considerable strain on their composition, which ultimately leads to their degradation. To ensure the cost-efficiency and longevity of a mission, it is necessary to properly design an electric power system with suitable battery technology. A precise knowledge of a satellite environment and its operation is required to develop experimental procedures, which could predict battery degradation. However, these tests can be very complex and time-consuming due to the large number of cycles, which the batteries experience during the mission of the satellite. Numerical simulations can bring valuable insight and accelerate these studies. This article presents a digital twin of a microsatellite model at LEO, which can be used for the analysis and prediction of battery characteristics. The training data was generated by combining numerical simulations and experimental measurements. Thermal simulations were carried out to study the temperature changes in batteries during various orbits. The empirical battery model was based on a measurement of battery characteristics at different current loads and temperatures. Experimental measurements of battery degradation at different temperatures were carried out to improve the predictive ability of the model. The model was then compared to an experimental measurement of battery performance, mimicking the in-orbit satellite operation, and the results were closely comparable. The advantage of the digital twin over classic numerical simulations lies in the possibility of real-time study and prediction of the system response to various inputs. Additionally, the resulting predictive model can be directly implemented into the satellite on-board computer, which in the future could be used for improved fault detection.