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LI-ION BATTERY OPERATIONS AND LIFE OPTIMIZATION

Abstract

The challenges in satellite operations are multi-fold. The battery management in a satellite is among the toughest challenges to any manufacturer and the operations team. The lifetime in orbit is most of the time defined by the battery health. This paper deals with the efforts undertaken at the German Space Agency (DLR) to optimize the battery life on their satellite TerraSAR-X. The TerraSAR-X was launched in 2007 and has successfully completed its design life of 5 years. In the past couple of years during the eclipse phase the battery voltages have dropped below the nominal end of discharge values. The satellite flies in a sun-synchronous "Dawn-Dusk" orbit where eclipses occur between April and August. Further, the duration of the eclipse in every orbit also varies during this period. The spacecraft has a power requirement of roughly 5000 W. During eclipse the full power required by the spacecraft bus and the payload is supplied by the batteries. In the summer of 2014 during the peak eclipse duration combined with instrument operations, a low voltage critical event was noticed. The same effect was noticed more than once during the summer of 2015. Although the noticed values were far from any safe-mode trigger limits it was an indication of some phenomenon other than the degradation within the batteries caused by ageing. It was found upon detailed investigation by the spacecraft manufacturer that the Li-Ion batteries show a secondary effect which at the initial stages of its life is considered negligible. This effect is called as the "diffusion rate effect". Several deep-discharge test cycles were performed in order to gather data for further investigation. Initial understanding of the tests showed that there was a sudden drop of battery voltage for even short payload operations but detailed investigation revealed that the drop is nearly linear beyond the first dip. Based on this discovery the existing battery model was optimized. This optimized model now accounts for the "diffusion rate effect" by controlling the maximum allowable discharge energy for every payload operation supported by the batteries. This paper discusses in detail the investigation, analysis of diffusion effect and the optimization of the battery model. The updated model was tested during the summer of 2016 and the results are presented in this paper.