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STATE-OF-CHARGE ESTIMATION AND PARAMETRIC IDENTIFICATION OF A GEOESTATIONARY SATELLITE LITHIUM-ION BATTERY CELLS DURING ITS OPERATION

Abstract

It is well known that the performance and health of a battery cell can be evaluated by analysing, among other properties, its State-of-Charge (SoC) value. Therefore, for a satellite operation it is critical to reliably estimate its battery cells SoC.

The Aerospace Operations Command (COMAE) is the responsible for the operation of the Geostationary Defense and Strategic Communications Satellite (SGDC-1), whose battery is composed by 24 lithium-ion cells. The battery is mainly used during the eclipse seasons, when its Electrical Power Subsystem (EPS) estimates a battery level SoC by cumulatively summing the battery current. However, the imprecision of this method provides non-reliable SoC values.

In order to evaluate and to predict the performance of each cell, COMAE has identified the necessity of better estimate their SoC during the solar eclipse seasons, and eventually acting to increase the cells lifetimes.

For such end, each cell was modelled after an equivalent circuit whose parameters were to be estimated using the current and voltage telemetries. Although this approach is quite common, it requires the beforehand knowledge of the Open-Circuit-Voltage (OCV) curve of the cells, which usually are not available to the operators. To work around this problem, the OCV curve itself has also been modelled and its parameters were estimated alongside the circuit parameters.

Hence, an augmented state was defined to include the statics variables (circuit and OCV curve parmeters) into the original state of dynamics variables (SoC and the internal voltages of the circuit). Then, the Extended Kalman Filter is used to perform the augmented state estimation for each cell, considering current as input and cell voltage as output.

From the telemetry data gathered at six eclipse seasons, the first four were used to calibrate the parameters while the last two seasons were used to validate them by comparing the predict output with the telemetry voltage.

As result, given the profile of the battery current during the eclipses, it was possible to forecast the behaviour of the cell voltage telemetry and to estimate the SoC value at least one week in advance. This prediction horizon is expected to increase after the next eclipses seasons, when more data will be collected, giving the operators a better tool to monitor the perfomances of the cells and detect unexpected behaviours.