Genetic Algorithm Based Charging Optimization of Lithium-Ion Batteries in Small Satellites

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Abstract

Small spacecraft that are powered by solar energy have limitations because of the size of their solar panels. The reasons for this are the size of the satellite itself, weight and cost issues. These issues are an inherent part of small satellite programs. With the limitations on the solar panel size, it is generally hard to comply with the demands from all the satellite subsystems, payloads and batteries at the same time. We confront similar issues with *VIKSAT1*, a small satellite prototype being developed at CSU. To overcome these problems we have developed and adopted a power management optimization scheme that runs in real time in the satellite. Though the scheme has been adapted to the specific needs of *VIKSAT1* it is general enough to be suited to a wide variety of spacecraft, from small satellites to cruisers that travel distant places.

The proposed power management scheme primarily involves scheduling of loads (various subsystem operations, payload experimentation, battery charging, etc.) so that power utilization is at its optimum. At the same time it controls the amount and rate of charge that comes out of the batteries during eclipse and that goes into the batteries during the day time. This battery management becomes even more important with the use of Lithium-Ion batteries. These batteries have the advantage of high power density and light weight, but are very sensitive to over charging and over discharging. The power management program involves breaking everyday satellite activities into 'tasks' that may be periodically updated from the ground. A task is then fitted into a 'template' that identifies the ultimate 'load' for the power distribution system, which comprises the regulators to the subsystems. A 'frame' is generated for each load which then gets stamped with a priority index, start time, end time, modularity, interrupt ability, correlation identifiers, and other auxiliary information. The loads are then fed to a Genetic Algorithm (GA) based optimizer with the corresponding frame contents as the constraints to the GA. The output is a queue that has a schedule of operations in it. Since Genetic Algorithms are computationally intensive, we propose an FPGA based implementation of it. FPGA implementation allows a coarse parallelism and pipelining on the same platform. This speeds up the GA runs and makes them suitable for real time implementation. The advantages and suitability of the proposed scheme are presented with some simulation and hardware test results for *VIKSAT1*.

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