SPACE POWER SYMPOSIUM (C3)
Small and Very Small Advanced Space Power Systems (4)

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ROBUST SIZING OPTIMIZATION OF SMALL SATELLITE POWER SYSTEM UNDER EPSITEMIC UNCERTAINTY IMPACTS

Abstract

A robust optimization method for small satellite power system design with distributed power balance is proposed. Impacts of uncertainties from power system components, environmental, and orbital parameters are investigated. During the mission, different power system operation modes of DET (Direct Energy Transfer), MPPT (Maximum Power Point Tracking), CV (Constant Voltage) of SAR (Solar Array Regulator) are conducted. Impacts of temperature, attitude and degradation effects of the solar array are varied; parameters of regulators and battery could be varied as well. Due to insufficient knowledge, such variations could not be modeled accurately. With uncertainty impacts from different disciplines, structure of the uncertainty space becomes complex and high computational cost is required for the design optimization. In this work, a new robust MOO with Tchebysheff decomposition is implemented for the design optimization. With Tchebysheff decomposition, the evidence based MOO is formulated into a set of scalar weighted optimization problems. Candidate solutions are decomposed into a set of principle components with various 'energies'. New searching space is then generated by spanning the principle components. A deepest descent like method is implemented for generating new candidates and searching the robust Pareto set. Impacts from high dimensional epistemic uncertain space are reduced through parameter model reduction techniques. Power balance of the loads and battery are integrated into the conceptual design. The power simulator estimates amount of power generated and consumed, depth of discharge, bus voltage, charging/discharging current of the Lithium Ion battery. Mass-power ratio of the system is optimized while at same time maximize its belief values under uncertainty impacts. Finally, numerical simulation of a micro LEO satellite power system design with distributed power balance is presented.