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IMPACT INDUCED FAILURES OF SOLAR ARRAY CABLE BUNDLES

Abstract

Satellite solar arrays expose the largest surface areas to the orbit environment. Environmental effects considered in solar array design are mainly radiation damages of the solar cell assemblies and, specifically for GEO environments, electrostatic discharges in the photovoltaic network. Less consideration is given to the effects of hypervelocity impacts of micrometeoroids and space debris. Similar to radiation effects, such impacts are assumed to degrade the power generating surface through locally damaging solar cells at the impact sites while the function of the solar cell itself is not impaired. The accumulated impact induced loss of photovoltaic area is typically lower compared to radiation induced degradation. Both are compensated through redundancy, i.e. oversizing the solar arrays to the end-of-life demand.

We have been able to confirm this approach in a comprehensive study to investigate the susceptibility of solar generators in the GEO. Impact-induced discharges and mechanical impact damages in the photovoltaic network can effectively mitigated through the common measures of redundancy and discharge prevention. However, we found a relatively high risk posed by impacts on the power transfer harness on the rear side of the solar arrays. Although the impact area of such cable bundles is much smaller, the effects are much more critical both in terms of critical impact conditions and consequences. The transfer harness cables on the panel rear side are at critical discharge conditions per se, as they collect the current produced in whole solar array sections. Dedicated impact experiments on operated representative power cable bundles showed that whole solar array sections can be short-circuited through impacts that severe at least two power lines having different polarity. The short-circuits were caused by severed cable ends getting into direct mechanical contact after the impact. The short-circuits were permanently sustained until they have been terminated by shutdown of solar array simulator input power.

In this paper we present the performed experiments on operated cable bundles of solar arrays along with an analysis of the risk of impact induced failures for a typical solar array in GEO. We found both critical risk levels but also high uncertainty caused by the non-uniformity of the bundle geometry and the routing of individual power lines within. The paper concludes with a discussion of shielding options in terms of shielding efficiency and system design impact.