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CRYOGENIC ELECTRONICS IN DEEP SPACE MISSIONS

Abstract

Instrumentation aboard a spacecraft in deep space require a consistent working temperature of around 293 Kelvin where as deep space has an ambient temperature of around 2.7 Kelvin, slightly higher than the temperatures maintained at the Large Hadron Collider at CERN. This requirement forces the satellite to contain a robust thermal control system consisting of multiple RHUs (Radioisotope Heater Units) and heat pipes among multiple other systems. This leads to the inefficient consumption of energy where a large amount is dissipated to maintain this ambient working temperature. A big challenge for these thermal control systems is to behave according to the phases of the spacecraft, ie. being able to both reject heat during the hotter operating phases of the spacecraft and also being able to push through the cold inactive phases.

This paper looks at cryogenic electronics as a replacement for multiple instruments, mainly power electronics, aboard deep space spacecraft thus simplifying and reducing the need for as many heating sources and saving large amounts of energy. These instruments would survive harsh deep space environments with ease, increase system efficiency, reduce payload development, reduce launch costs and use the extremely low temperatures to our benefit for improving circuit performance. Cryogenic low noise amplifiers are also used extensively for deep space communication.

Power electronics working in these low temperatures have proven to be much more efficient than their room temperature counterparts as they exploit the nature of materials to have better electronic, electrical, and thermal properties at extremely low temperatures such as that of deep space. Research has shown that certain semiconductor devices perform well at lower temperatures, as they will have a smaller on-resistance and a higher switching rate. This implies that operating power electronics systems at cryogenic temperatures will result in decreased power dissipation, as well as reduced volume and weight.