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Author: Mr. Siddharth Tiwari
Sonaca Space GmbH, Germany

Dr. Matthew Dalton
Sonaca Space GmbH, Germany
Mr. Riccardo Nadalini
Sonaca Space GmbH, Germany

DEVELOPMENT OF THERMAL CAPACITORS FOR TEMPERATURE REGULATION IN SPACECRAFT

Abstract

Spacecraft electronics, which have cyclical operation, may experience short periods of large heat production (heating phase) requiring large radiators for heat rejection, as well as periods of low power consumption (cooling phase) requiring heaters to keep the electronics within their safe temperature range due to excess heat loss via the radiators. A thermal capacitor, containing Phase Change Materials (PCMs) that exhibit a very high heat capacity near their transition temperature (latent heat), may be placed between the heat producing electronic component and the radiator to store the excess heat in the form of a physical change in the state of matter during the heating phase and release it back to the component during cooling phase. Thus, PCM based thermal capacitors can passively moderate the temperature fluctuations of the electronic component, holding the temperature near the transition of the PCM and thus improving its performance and longevity, and in the process also reducing the required size of the radiators and power consumption of heaters during the cooling phase. Thermal capacitors have seen limited use, for example aboard the Lunar Rover Vehicle for the Apollo 15 Mission, yet there are still many applications which could benefit from passive thermal control, for example Earth orbiting satellites which transmit data only during short bursts while passing over communication installations on the ground. Modern PCMs are synthesized artificially and can be engineered to have the desired physical properties such as melting temperature, latent heat, thermal conductivity and volumetric expansion. Additionally, modern techniques to deliver the heat more efficiently to the PCM matrix and fine tune the thermal response for the expected mission parameters highlight the advantages these devices can bring. Current RD efforts by Active Space Technologies to design prototypes and performance models of thermal capacitors to fine tune the thermal response for a range of spacecraft (power dissipation, operating temperatures, duty cycle, etc.) scenarios will be presented.