Passive PCB Mounted Thermal Switch

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Abstract

A printed circuit board (PCB) generates heat during operation. In a vacuum this heat can only be rejected by conduction and radiation. To reject heat effectively and avoid overheating, the PCB needs to be thermally conductive to the electronics enclosure. However, if the system rejects too much heat, or not enough heat, either can result in system failure. The thermal switch will be able to regulate the amount of heat the system rejects to stay within the operational temperature range.

Problem Statement

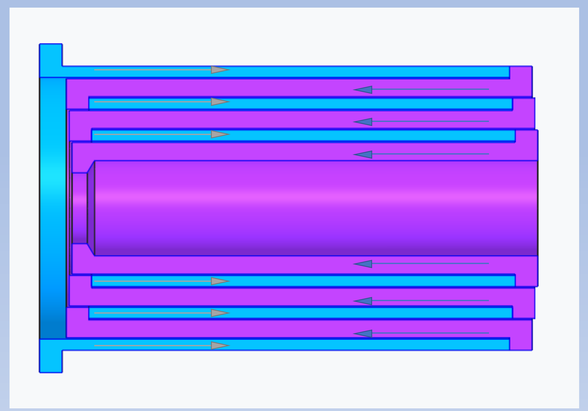
There are many thermal challenges with electronics in a space environment. Almost all excess heat from electronics is rejected through conduction to it's enclosure and then the vehicle chassis or equipment shelf. When heat rejection is required, low thermal resistance is preferrable, but can be detrimental if thermal isolation is required instead.

Solution

A solution is to create a mechanism that mounts directly to electronics boards that can have a low and high thermal conductivity mode. When there is excess heat on the board to dissipate, the mechanism will close and allow conduction. When the board cools, the mechanism will open to thermally isolate the board.

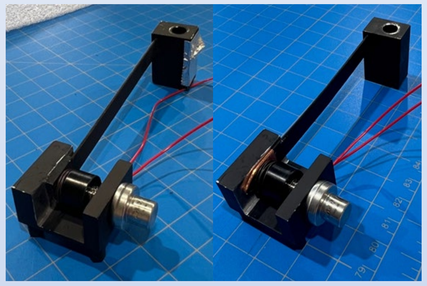
CTE Piston

Although using a wax motor is a cost-efficient solution, it was deciding that using a piston with layers of different materials possessing different coefficient of thermal expansions (CTE), would give us the best thermal performance. The amount of heat transferred is proportional to the amount of pressure applied to the surface. The CTE piston can output 6.5x more pressure than the wax motor.

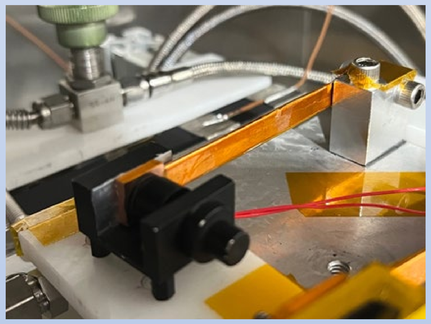


Layer	Material	CTE [ppm]
Blue	Aluminum 6061	23.6
Purple	Allvar 30	-30

Wax Piston With Heat Pipe



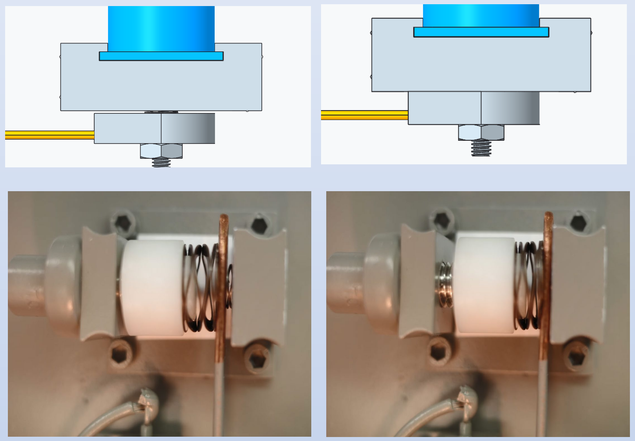
Soldered Heat Pipe Maximizes Conduction



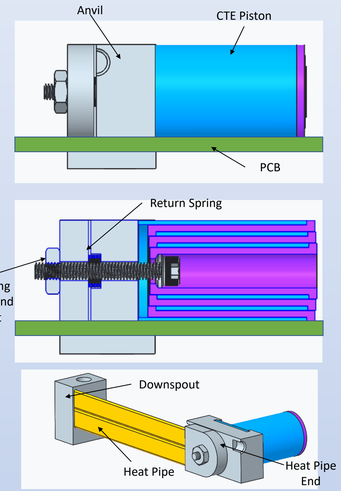
CTE Piston

Two Thermal Conductive States

Low Thermal Contact | High Thermal Contact

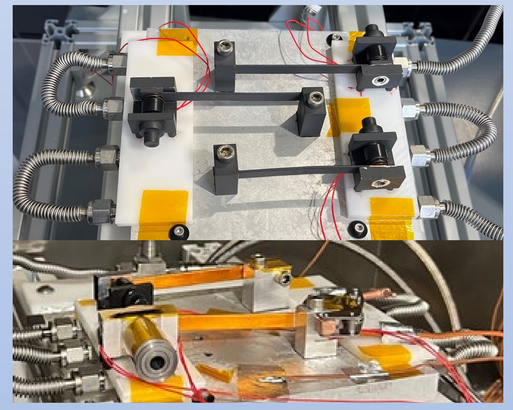


Switch Design

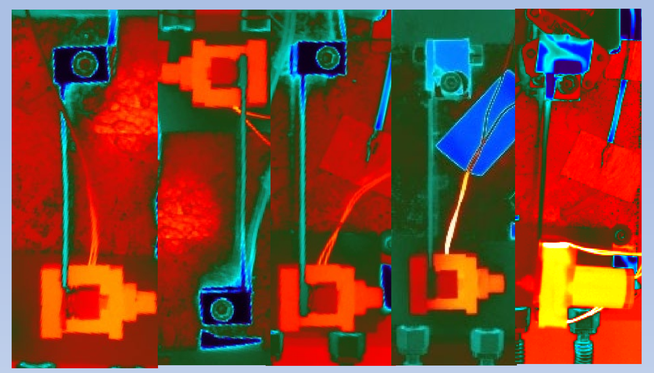


Test Set Up

- Large resistor generates heat to represent a heat generating IC
- Linear wax motor provides motion to push heat pipe into contact with anvil
- Heat flows through the heat pipe to a thermal downspout with the baseplate acting as a sink
- Test conducted in a vacuum with thermocouple and IR camera instrumentation



Test Results



Test Specimen	COP	k/L [W/m^2K]	R [W/K]
Copper Heat Pipe	23.5	498.4	12.4
Aluminum	36.4	431.7	14.4
Aluminum w/ Grease	47.8	654.0	9.5
Soldered Heat Pipe	76.2	1241.8	5.0
CTE Piston	175.6	762.8	8.2