HIGH PERFORMANCE THERMAL SWITCH FOR LUNAR NIGHT SURVIVAL. D. C. Bugby[1], P. E. Clark[1], and D. C. Hofmann[1], [1]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109, david.c.bugby@jpl.nasa.gov, pamela.e.clark@jpl.nasa.gov, douglas.c.hofmann@jpl.nasa.gov.

Introduction: A high performance differential thermal expansion (DTE) thermal switch was developed to enable solar/battery lunar surface science payloads. Previous DTE thermal switches (e.g., MSL SAM) are ON/cold, OFF/warm. For lunar night survival, this "normal-operation" DTE thermal switch must be reversed to OFF/cold, ON/warm. This paper describes a patent-pending JPL-developed "reverse-operation" DTE thermal switch that performs as follows: ON conductance of 5 W/K, OFF conductance of 0.002 W/K, and ON/OFF switching ratio of 2500:1.

Background: The thermal design challenge facing lunar solar/battery-powered instruments is how to reject payload heat during the day yet isolate the payload enough during the night for battery mass launch viability. A Lunar Geophysical Network (LGN) study indicated a 400:1 thermal switching ratio is required for battery mass viability. The ratio must be even higher for compact lunar payloads under development at JPL. The NASA 2015 technology roadmap TA14 indicates a need for a thermal switch 10X better than the state-of-the-art 100:1 MER paraffin thermal switch.

Concept: Two prototypes were designed, built, and tested. Their basis of operation is the mating/de-mating of parallel (near mirror finish) flat metal surfaces. The physical mechanism causing the motion is the DTE of mid-CTE, high thermal conductivity (k) metallic end-pieces compared to a low-CTE, low k two-piece metal/polymer support beam. The requirements of operation were to be fully ON above 300 K with 1335 N force and fully OFF below 260 K.

Design: The thermal switches were designed for seamless integration into box-type instrument enclosures. Each prototype easily slides into a small 25-35 mm circular enclosure opening such that most of the 80-120 mm long thermal switch lies within the enclosure and just two small circular 25-45 mm diameter, 6 mm thick discs (one connects to a radiator) are visible from the outside of the enclosure. Figure 1 illustrates how the design would be integrated into a notional IR camera. Also shown is a prediction of the instrument thermal response during a 10º latitude lunar day.

Fabrication: A technique was developed that ensures the mating surfaces are highly parallel to promote a high uniformly applied ON force and a flat uniform OFF gap, where the OFF thermal path is solely through the low k support beam. To achieve high ON force at room temperature, the support beam is sized (δ) shorter than the space between the end-pieces. During assembly, the support beam is stretched by δ to provide the ON pre-load. To ensure highly parallel surfaces, a sequence of machining operations and digital profilometer readings obviates the need for metallic shims.

Modeling: Pre-test predictions of reverse-operation DTE thermal switch prototype performance indicated ON conductance of 2.5 W/K based on the metal contact heat transfer coefficient correlations [1] and OFF conductance of 0.002 W/K assuming just conduction through the assembly with a completely open gap (radiation ignored). An open gap was predicted to occur at 273 K for one prototype and 283 K for the other.

Testing: Two testing stages were carried out. The first stage (on lab bench) sprayed aerosol freeze-spray onto each prototype and measured temperature. Electrically non-conductive polymers in the OFF condition flow path allowed electrical resistance to indicate the ON/OFF transition, which verified the pre-test predictions. The second stage (in thermal vacuum) was conducted with a calibrated Q-meter, which demonstrated performance that doubled pre-test ON conductance and was in-line with pre-test OFF conductance predictions. The two prototypes are illustrated in Figure 2.

Conclusion: A high performance reverse-operation DTE thermal switch was developed that will enable future lunar/planetary solar/battery instruments to survive/operate through the lunar/planetary night.

References:

[1] Hattori, T. , et. al (2001), *Transactions on Engineering Sciences*, *32*, WIT Press, ISSN 1743-3533.

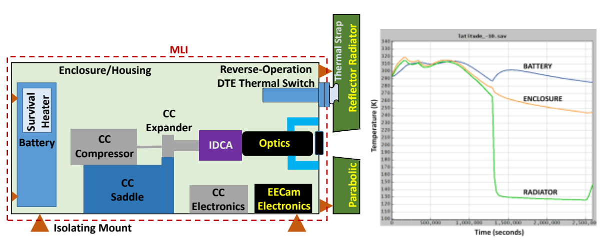

Figure 1. Reverse-Operation DTE Thermal Switch Enables Notional IR Camera to Stay Warm Through Lunar Night

Figure 2. Reverse-Operation DTE Thermal Switch Prototypes