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THERMAL MODEL FOR A MARS INSTRUMENT WITH THERMO-ELECTRIC COOLED FOCAL PLANE: CCD SUBSYSTEM RESULTS

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ABSTRACT

The Mineral Identification and Composition Analyzer (MICA) is a miniature instrument that employs X-ray scattering and visual imaging to determine nondestructively the mineralogy of a rock sample in-situ. Results for the System Thermal Model, including one special case for the CCD Subsystem Model, were previously reported [1]. The CCD subsystem comprises the CCD focal plane, the thermoelectric cooler (TEC), the TEC heat sink, a passive heat switch, and the subsystem radiator. The TEC is used to hold the CCD focal plane at or below 208 K during instrument operation. The inclusion of the heat switch and TEC are found to significantly extend instrument observation times and to enable schedule flexibility during extreme Martian diurnal temperature excursions, including atmosphere (~175 K to 255 K), sky (~130 K to 200 K), and convection (wind) effects. The CCD Subsystem Model includes all parasitic and dissipative heat sources, such as heat leaks from MICA electronics, CCD and TEC dissipation during active status, and parasitic heat loads to the focal plane and heat sink. The model incorporates logic that allows the heat switch to provide heat sink cool-down by night and isolation by day if a sufficient temperature difference exists between the radiator and the sink, which must not exceed 258 K for efficient cooler performance. Model parameter variation allows the instrument designer to optimize the subsystem thermal capacities and thermal resistances to minimize input power to the TEC and maximize instrument observation periods. This paper extends previous results to include various combinations of the heat switch status (open / closed), the TEC status (active / inactive), and the ambient environmental condition (warm / cold), for various input parameters.