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Cryogenic Motion Control

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As spacecraft are sent to extreme environments, the demands on the instrumentation and components of the spacecraft increase Low temperature operation is desirable for instrumentation because it improves the signal to noise ratio on detectors enabling more sensitive scientific investigations.

Actuators are used for restraint and release of deployable components of spacecraft such as antennas, booms, and other appendages. Drive mechanisms supply the energy needed to move components from position to position. Solenoids, voice coils and electric motors can be used to provide the desired motion for mechanisms. While the design of many of these mechanisms are well understood, operating them at cryogenic temperatures require considerable attention to several critical issues including thermal contraction, changes in electrical and magnetic properties of materials and careful design of sliding, rolling and flexure bearings that enable the motion. Cryogenic lubrication is limited to dry systems since all hydrocarbon-based lubricants freeze at these temperatures.

Both piezoelectric and magnetostrictive actuators have been prototyped for cryogenic operation. These materials elongate in proportion to an applied electric and magnetic field, respectively. Although piezoelectric materials can be made to operate at cryogenic temperatures, their performance is decreased by a factor of 5 –10 at cryogenic temperatures. Furthermore, typical piezoelectric actuators must operate at voltages of 500-1000 V. Generating this high voltage from solar panels requires special electronics that add to system weight.

Magnetostrictive materials are available that demonstrate very high performance at cryogenic temperatures. These materials have Curie temperatures below room temperature. A new magnetostrictor, KelvinAll, has excellent magnetostriction over a broad range of temperatures from near absolute zero to above 400 K. Many types of cryogenic actuators and linear stepper motors have been demonstrated based on this material.