

***External Phase Shifting Tuning Mechanism
in a Miniature Pulse Tube Cryocooler
Using a Semi-Active
Electromagnetic Damping System***

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A semi-active electromagnetic damping mechanism was developed to externally control the phase shift and amplitude at the hot end of a pulse tube (PT) cryocooler. The semi-active phase shift (SAPS) mechanism was designed, built and tested, and included a voice coil suspended on a silicon diaphragm and a flexural bearing. The development included theoretical calculations, numerical optimization using SAGE®, flexure bearing optimization and development, off-the-shelf voice coil selection and modal simulations of the entire system using ANSYS® finite element software. The goal was to obtain the optimum phase shift between pressure and flowrate and thus reach the optimal cryocooler performance. During experiments, a stick-slip phenomenon inherent to the voice coil influenced the cryocooler performance, and the lowest temperature observed in the experiments was 225K (without vacuum in the containing chamber) at 100 Hz operational frequency. However, the results show that the system was capable of externally tuning the cold end temperature, and provided a proof of concept for the application of external phase shift and amplitude tunable mechanism.