Piezo Motors

Michigan Aerospace developed nanopositioning technology, incorporating piezoelectric actuator (PZT) technology, for use with tunable Fabry-Perot etalons. The purpose of the nanopositioning motors is to position the etalon plates parallel to each other at a specific distance, and to maintain that geometry over a range of time and temperatures. To achieve this goal, the PZT actuated nanopositioning motor, or Force Motor, is comprised of three sub-systems: the PZT actuator itself, a capacitive measurement system, and an invar rod.

The Invar rod maintains, roughly, correct plate spacing between the etalons. For large gapped etalons long rods are used, for small gaps small rods are used. Between the PZT motor and the spring ring is an Invar washer that can be easily removed, lapped, and returned to the system to make course adjustments of the etalon spacing and parallelism of the etalon plates.

Piezo devices expand and contract based on the voltage potential applied across the material. Piezoelectric materials have significant hysteresis, so relying on the applied voltage to determine the length of the piezoelectric cylinder is not feasible. To determine how much the piezoelectric cylinder has expanded or contracted, a capacitive feedback system is used. Michigan Aerospace's force motor and controller design allows for the feedback mechanism to be installed within the motor itself or to be taken from an external source.

The Force Motor Design

Michigan Aerospace has achieved a thermally stable, durable piezo motor design called the "Force Motor". It is fundamentally an innovative means of utilizing a piezoelectric actuator with capacitive feedback for applications that require a high degree of ruggedness in a very small and lightweight package. The design utilizes a central structural member that is stretched by the piezoelectric element to increase its rigidity and robustness. Due to this design, the motor will withstand a modest bending moment. The central stretching member removes the PZT element from the load path of the motor when the motor is relaxed. This prevents damage to the piezoelectric element during assembly, or when used in demanding environments, such as a launch into space. When the piezoelectric element is powered, this central structural member also improves the failure strength of the assembly to further increase the robustness of the motor design.

For applications where it is desirable to integrate the feedback system into the motor body, a metering system which exploits both positive and negatively thermally dependant components is employed. The result is a length measurement system that has nearly zero thermal expansion and provides a true measure of the overall behavior of the motor. This design has been fully vibration tested for space launch within a working etalon model and has achieved high finesse in a vibration tested mount. Typically, the quest for high finesse reduces the robustness of a mount in terms of vibration survivability. An optimal balance was achieved.

Force Motor Specifications

	Room Temperatures	Cryogenic Temperatures
No Load Range	4 microns	20 microns
Tuning Accuracy	0.04 nm	0.04 nm
Motor Length	30 – 150 mm	50 – 150 mm
Motor Diameter	16 mm	13 mm
Material	Invar 36	Invar 36
Piezoelectric Material	Standard Ceramic	Single Crystal Ferroelectric
Mechanical interface at ends of motor	Standard M5 x 0.8 thread although other interfaces are available	