

Optical Products

Etalons & Accessories for Interferometers

Tunable, Solid or Fixed-Gap Etalons

Nano-Positioning and Control Systems

Custom Fiber Assemblies

Custom Mounts

...from concepts to products.
...from concepts to products.

Michigan Aerospace Corporation is an Advanced Engineering
& Products company specializing in:

Atmospheric LIDAR

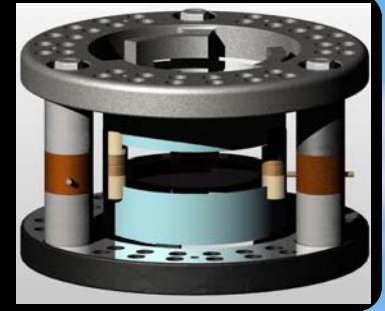
Optical Remote/In-Situ Automated Detection

Mechanical & Opto-Mechanical Systems

Data Exploitation

Tunable Fabry-Perot Etalons

Etalon Design: The Michigan Aerospace etalon design is the result of decades of development for systems operating in space, on aircraft and in the laboratory. While the majority of the etalon hardware developed at MAC is not intended for spaceflight, the robustness derived through these space hardware initiatives confers benefits to all applications using Fabry-Perot etalons. The etalon product that has resulted delivers the highest level of stability and performance available anywhere in the world. Highlighted below are several aspects of the Michigan Aerospace etalon design that enable its exceptional ruggedness, stability and superior optical performance.



Intra-Gap Capacitive Feedback System: In order to provide continuous feedback on the changes in the gap of the etalon, three sets of gold-coated capacitors are bonded directly to the etalon plates. The substrate for the capacitor body is typically Zerodur and is manufactured to match the radius of curvature of the plates, which minimizes stresses imparted to the plates from the bonding process. The use of Class 0 Zerodur for the capacitors ensures that the thermal contributions from the feedback system is virtually zero.

Spring-Arm-Mounted Ring Geometry: The geometry of the rings used to hold the etalon plates are the result of extensive mechanical and thermal analysis. The concentric arms which extend into the aperture of the etalon are designed to minimize the radial stress imparted to the etalon plates due to deformations induced in a thermally-dynamic environment. This design allows our etalons to operate over a wide range of temperatures with virtually no degradation of finesse or throughput.



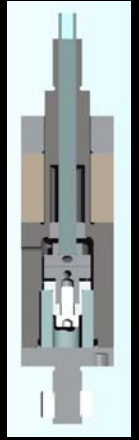
Invar construction: All of the metallic structural components of the Michigan Aerospace etalon are fabricated using heat-treated and stabilized Invar 36, which ensures that the etalon structure has exceptional thermal stability and uniformity even in the most demanding environments.

Etalon Specifications:

| Parameter | Standard (As Shown) | Available |
|---|-------------------------|--|
| Etalon Gap | 1.5 cm | 0.005 - 8.5 cm |
| Dynamic Tuning Range | 3 microns | Up to 20 microns with ferroelectric actuation |
| Etalon Clear Aperture | 5.0 cm | Up to 15.0 cm |
| Surface Quality | $\lambda/150$ @ 633 nm | Surface quality of up to $\lambda/200$ available |
| Wavelength(s) | 355 nm | Broadband or single-wavelength coatings available from deep IR to UV |
| Operating Temperature | 10 - 50 °C | Cryogenic or room-temperature designs available |
| Etalon Stability | 0.2% FSR @ 355 nm | N/A |
| Etalon Controller Resolution | 20 bit | N/A |
| Piezoelectric Drive Voltage | 0 - 900 V | May be adjusted for optimal balance of dynamic range and resolution depending on application |
| Control Electronics Operating Temperature | 0 - 30 °C | N/A |
| Controller Size | 3U Rack-Mount Enclosure | Housing can be modified to suit specific dimensional requirements |
| Controller Interface | RS-232 | Uses either API or Michigan Aerospace Corp. Windows control program |

Nano-Positioning and Fiber Assemblies

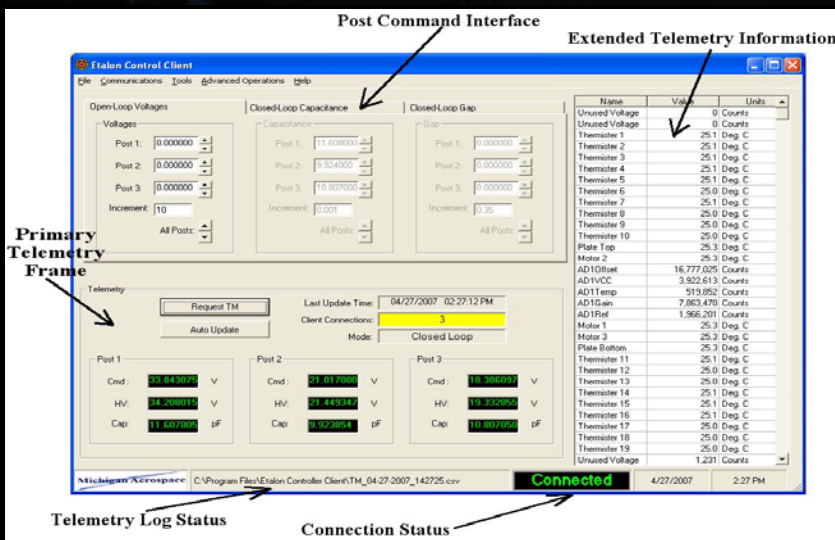
Piezoelectric Nano-Positioners: Michigan Aerospace Corporation has developed piezoelectric-based nano-positioning technologies that offer compact, precise and robust positioning of optical components and elements. Utilizing stacked ring piezoelectric actuation with capacitive feedback control, in conjunction with our patented force motor technology, our actuators are designed to be integral structural members of an assembly that keep the delicate piezoelectric element out of the structural load path. Our force motor designs include both integrated capacitive feedback, as shown here, or may be designed for use with an external source of feedback.



Michigan Aerospace's nano-positioners, when used with our analog servo controller, offer a 3-5 microns range of motion with standard ceramic actuators and up to 30+ microns utilizing ferroelectric actuators. Michigan Aerospace has produced nano-positioning designs for use in all types of environments including non-dynamic room temperature lab applications, space qualified hardware applications and high vacuum cryogenic applications.



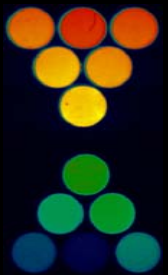
Nano-Positioning Digital Servo Controller: Michigan Aerospace Corp. has developed a programmable digital controller for use with its piezoelectric positioning systems. The controller has up to three channels and can operate in open or closed-loop modes. When operated in closed loop mode and coupled with a capacitive feedback system, this controller provides sub-nanometer stability and resolution.



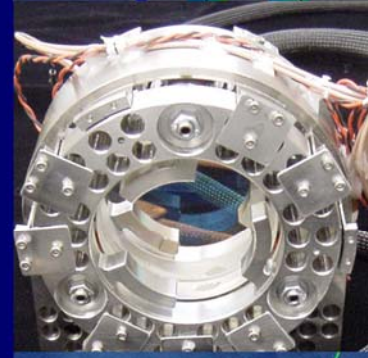
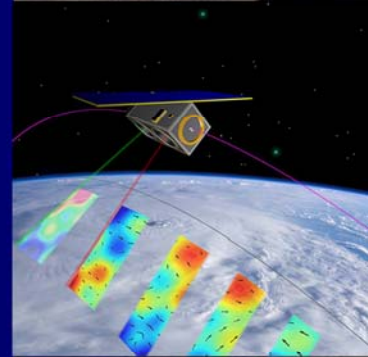
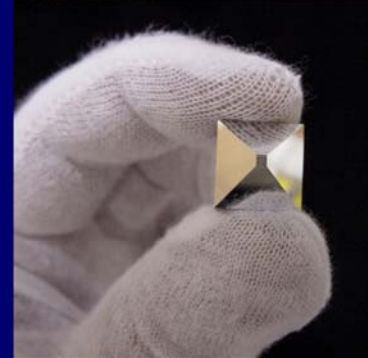
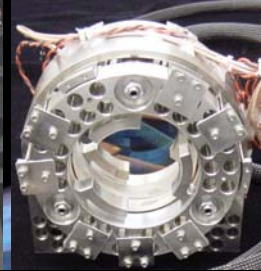
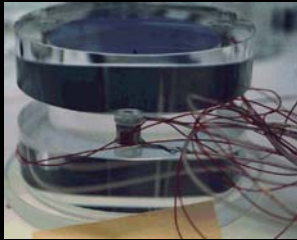
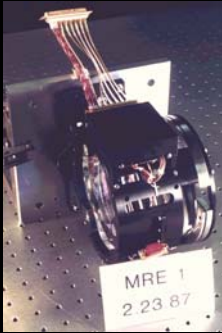
Because this controller utilizes digital technology, the user can control motion to sub-nanometer levels using discrete, absolute motion intervals. Additionally, it enables the user to program, both through the provided GUI as well as by using external routines and programs (such as IDL), a wide variety of continuous scanning and/or step-and-dwell routines for our nanopositioning system.

In addition to positioning control, the controller also has the capacity to retrieve and store instrument telemetry, including not only that pertinent to the nanopositioning system, but also environmental parameters. With inputs available for up to 32 channels, this controller is able to retrieve and store telemetry regarding environmental temperatures, pressure, or any other point of telemetry whose output can be read as a voltage.

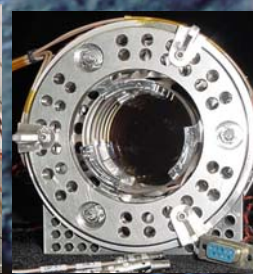
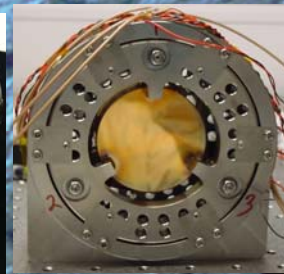
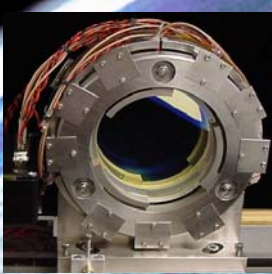
Custom Fiber Optic Assemblies: Michigan Aerospace Corp. designs, assembles and tests high precision custom fiber optic assemblies for all of its optical instruments. For optimal system performance, our cutting edge wind lidar technology requires the use of high precision fiber assemblies that incorporate unique geometric arrangements. Shown to the right is an example of a fiber arrangement that required fiber placement tolerances on the order of a few microns. The fiber optic assemblies that have been developed have been quite diverse in their specific geometric arrangements as well as the number of fibers incorporated and their diameters. The patterns have included configurations that had hexagonal and cubic close packing with fiber diameters that ranged from 150 to 400 μm .



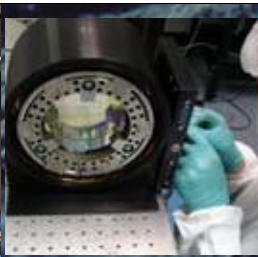
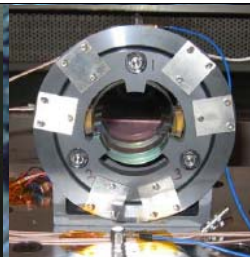
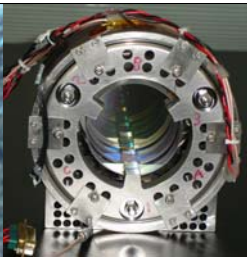
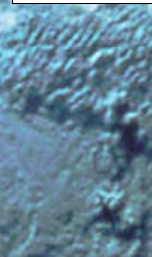
Etalon Heritage



| Project | HRDI | GLAS | GroundWinds | CALIPSO |
|----------------|------------|--------|-------------------------|---------|
| Year | 1987 | 1999 | 2000-2003 | 2002 |
| λ | 550-780 nm | 532 nm | 532 nm GWNH/355 nm GWHI | 532 nm |
| Clear Aperture | 94 mm | 40 mm | 42 mm | 42 mm |
| Reflectivity | 0.88 | 0.80 | 0.86 | 0.80 |
| # Etalons | 3 | 1 | 4 New Hamp.; 2 Hawaii | 1 |



| Project | SOFDI | Large Aperture Etalon | IR Cryogenic Phase II | BalloonWinds |
|----------------|------------|-----------------------|-----------------------|--------------|
| Year | 2003 | 2004 | 2004 | 2005 |
| λ | 550-830 nm | 532 nm | 10-12 μ m | 355 nm |
| Clear Aperture | 88 mm | 150 mm | 50 mm | 50 mm |
| Reflectivity | 0.80 | 0.95 | 0.80 | 0.70-0.80 |
| # Etalons | 3 | 1 | 1 | 2 |



| Project | TWiLITE Triple Aperture Etalon | LTIF Silicon Carbide Etalon | IIG Large Aperture Etalon | Geostationary Imaging Fabry-Perot Spectrometer |
|----------------|--------------------------------|-----------------------------|---------------------------|--|
| Year | 2006 | 2007 | 2008 | 2008 |
| λ | 355 nm | 355 nm | 630 nm | 600-750 nm |
| Clear Aperture | 50 mm | 50 mm | 100 mm | 50 mm |
| Reflectivity | 0.76 | 0.76 | 0.8 | 0.8 |
| # Etalons | 3 | 1 | 1 | 3 |

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