Sensors 2001 Report

Vibration sensors:
We need a sensor with $<1 \text{nG/Hz}^{1/2}$ sensitivity. The expected performance of the 2Hz capacitive accelerometer under development is $\sim 0.1 \text{nG/Hz}^{1/2}$.

Piezoelectric Accelerometers: Most vendors manufacture piezoelectric accelerometers with $\sim 1000 \text{nG/Hz}^{1/2}$ sensitivity. These could be used for high frequency sensors in conjunction with a low frequency seismometer, but could not be used as the sole vibration sensor.

*PCB piezotronics* claims 60nG/Hz$^{1/2}$ for their 383B31 sensor. We have used these sensors, and measured noise levels $\sim 2000 \text{nG/Hz}^{1/2}$.

Capacitive accelerometers: are designed to measure acceleration down to DC. Noise level is higher than for Piezo accelerometers. *Kistler* manufactures a sensor with 38,000 nG/Hz$^{1/2}$ sensitivity.

Aircraft inertial navigation accelerometers have good calibration, but have typical noise of $>1000 \text{nG/Hz}^{1/2}$.

MEMS accelerometers: *Silicon Designs* manufactures a MEMS accelerometer with $2000 \text{nG/Hz}^{1/2}$ noise (and a 600Hz resonance).

*Applied MEMS* manufactures an analog sensor with $800 \text{nG/Hz}^{1/2}$ Noise. A digitally controlled (on the chip) obtains $30 \text{nG/Hz}^{1/2}$. Unfortunately the data delay in this unit ($>30 \text{ millisecond (?)})$ is probably too long.

Fiber Accelerometers: The Naval Research Laboratory has fiber-optic accelerometers intended for submarine use. These have sensitivities as low as $16 \text{nG/Hz}^{1/2}$. The resonant frequency of this system is not specified. A “minimum detectable acceleration” of $5 \text{nG}$ is listed but not defined. The NRO units are R+D items, and they are looking for partners for commercialization.

No suitable Vibration sensors were found.
Other Equipment for Vibration Stabilization:

Position / displacement sensors:

Fiber optical position sensors with $0.35\text{nm}/\text{Hz}^{1/2}$. resolution, and 25 micron range are available from Philtec. These might be used for ground reference sensors.

Capacitive position sensors from MTI instruments have resolutions of $\sim1\text{nm}/\text{Hz}^{1/2}$. These sensors use 100KHz excitation. There was some interest in developing a product using our 10MHz excitation, with X100 better noise performance. Could be used as ground sensors, or (with improved resolution) as accelerometer sensors.

Electronics:

Precision Filters Inc. manufactures active filters for DC - audio band applications. A low noise front end amplifier / filter would cost $\sim$800 / channel (in VME format). This could be an alternative to the SLAC - built NIM amplifiers. Noise performance is not as good as our amplifiers.

DAQ systems:

National Instruments has PXI (compact PCI with some additions) “real time” data acquisition systems. They have demonstrated closed loop operate at $\sim$30KHz for a single channel PID loop. Might scale to our application, but probably is marginal. They are developing a new real time system with higher performance, but no information is available at this time.

Several companies, including Pacific, and Mars Labs manufacture data recorders. None are designed for closed loop operation. Most are PC based.
Ultrasonic Sensors

The NLCTA work requires ultrasonic (few x100KHz to few x 1MHz) sensors. Several companies manufacture low cost sensors which might be compatible with our data acquisition system.

**Ultrasonic sensors:** Airmar and International Transducer Corporation manufacturer ultrasonic sensors with MHz frequency response. Per unit costs are ~$10-$20.

**Piezo sensors:** Morgan electro ceramics manufactures small piezo elements. Can sell a small chip with attached wires for ~$10 each.

There are several options to replace our home-built sensors (and the expensive ultrasonic emission sensors) with lower cost units.

**Water flow**

**Coriolis Force sensor:** Fluid Components International claims absolute accuracy of 0.1% mass flow for ~10Gpm water flow. Could be used for measuring power dissipation in loads and structures.

**Turbine flow meter:** Cox claims 0.25% absolute accuracy for turbine flow meters. Has models designed for clean water.

**Other**

**Laser Vibration Measurement:** Ettemeyer claims 50-100nm resolution for an imaging laser interferometer. System cost is ~$300K. One time test is ~$20K. Could be used to look at water flow induced vibration in structures.

**Thin Silicon:** Virginia Semiconductor can make very thin Si samples. 6 micron thick is available. Note: a 20 micron sample was partially transparent. Can also machine Si. Possible application for Transition Radiation Monitor. Cost ~$1000 for a batch.

**Surface Roughness:** Hohner Corp manufactures a surface roughness (actually a scattering measurement) instrument for ~$1000. Could be used for the liquid metal collimator (will work through the vacuum window).