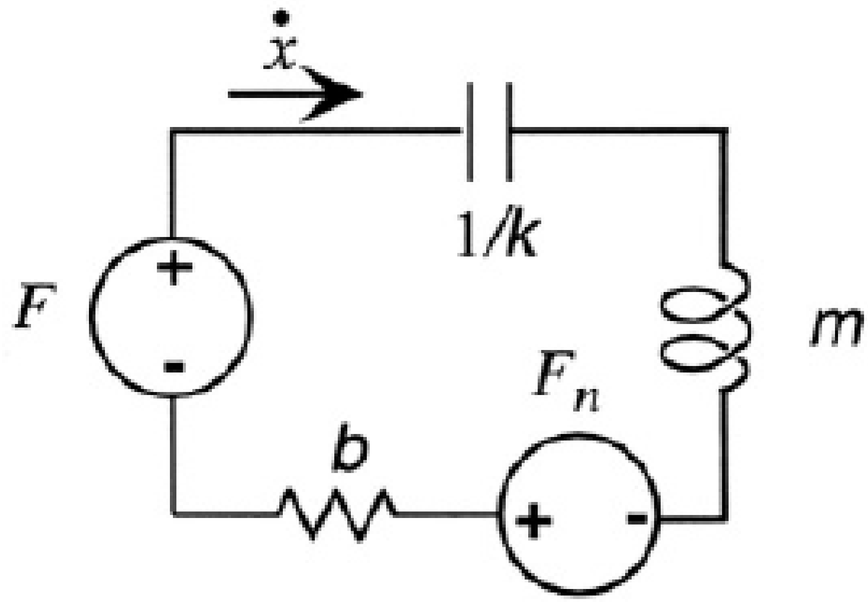
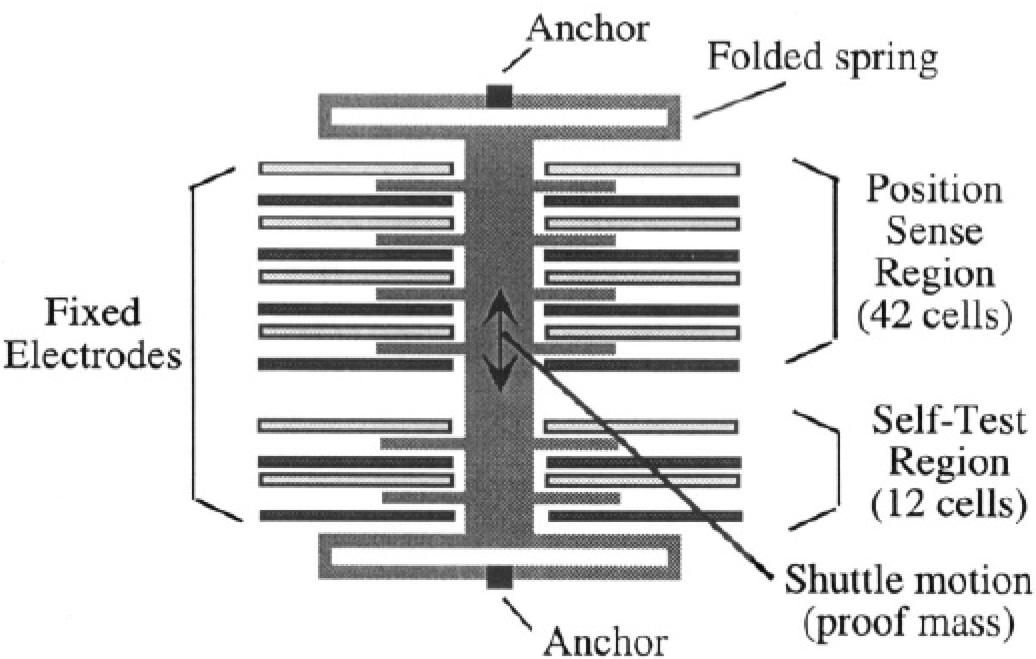
EE 245 Discussion Section 9/12/2011

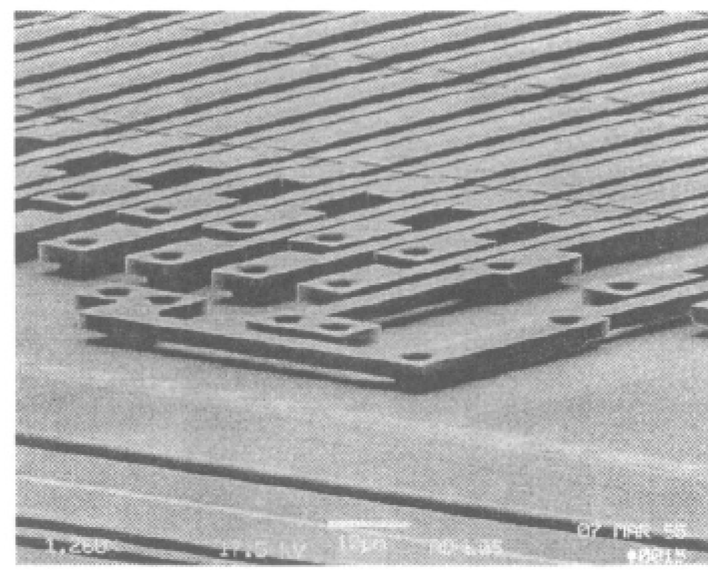
- Unless otherwise noted, all material taken from Senturia *Microsystems Design*: http://www.springerlink.com/content/978-0-7923-7246-2/

Accelerometers: F = ma

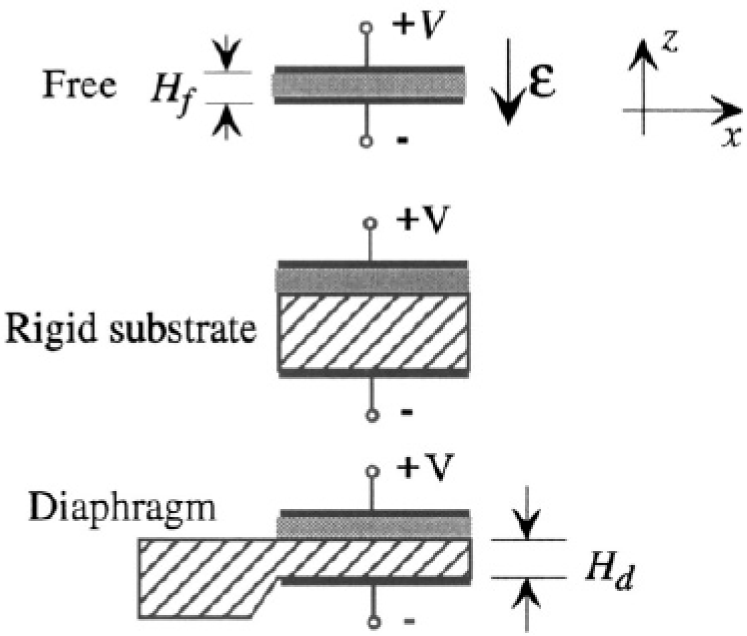


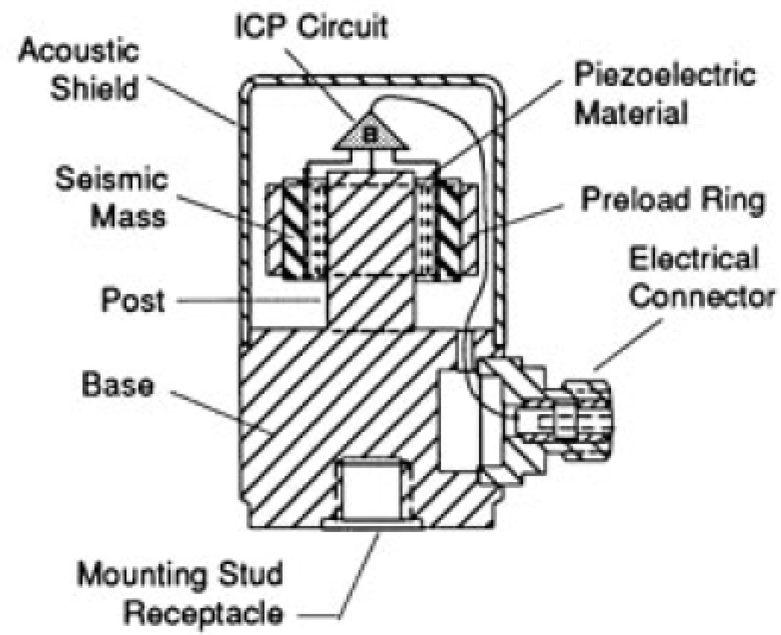
Capacitive Sensing





Piezoelectric Sensing



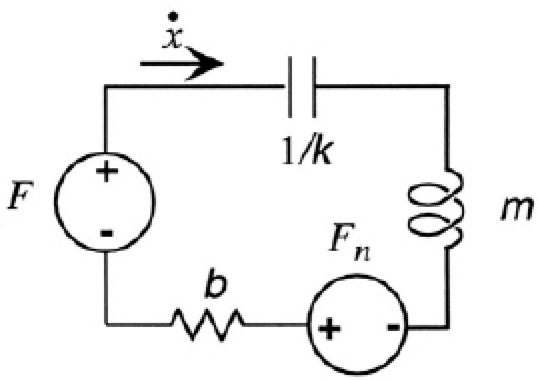


http://www.pcb.com/techsupport/tech_accel.php

Shear Mode

Shear mode designs bond, or "sandwich," the sensing crystals between a center post and seismic mass. A compression ring or stud applies a preload force required to create a rigid linear structure. Under acceleration, the mass causes a shear stress to be applied to the sensing crystals.

This system has an undamped resonant frequency ω_o equal to $\sqrt{k/m}$ and a quality factor Q equal to $m\omega_o/b$.



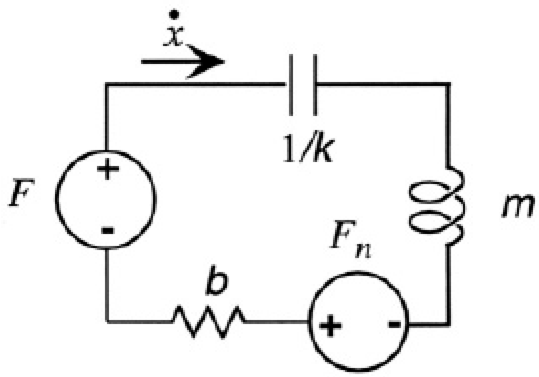
$$\dot{x} = sx = \frac{F + F_n}{ms + b + k/s}$$

$$x = \frac{F + F_n}{ms^2 + bs + k}$$

ω_o equal to $\sqrt{k/m}$

$$x = \frac{F + F_n}{k}$$

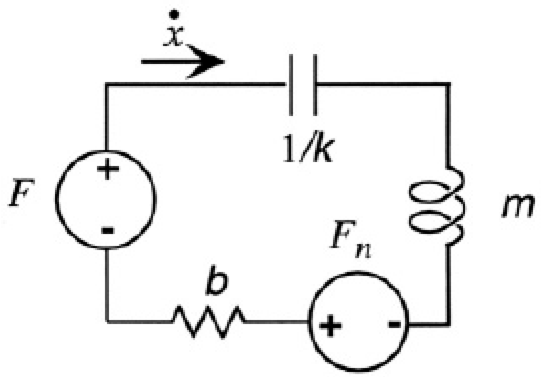
We examine, first, the signal term, then the noise term. The inertial force F equals the proofmass m times the acceleration to be measured, denoted here by a. This, together with the definition of ω_o, leads to a fundamental characteristic of quasi-static accelerometers. The displacement and acceleration are scaled by the square of the resonance frequency:



$$x = \frac{F + F_n}{k}$$

$$x = \frac{a}{\omega_o^2}$$

We now consider the intrinsic noise due to damping. The spectral density function of the force noise is $4k_B T b$, just like Johnson noise in a resistor. This noise typically arises from fluid damping. It is called *Brownian motion noise,* although in fact, the form of the force-noise spectral density function does not depend on the specific mechanism producing the damping.



$$x = \frac{F + F_n}{k}$$

ω_o equal to $\sqrt{k/m}$

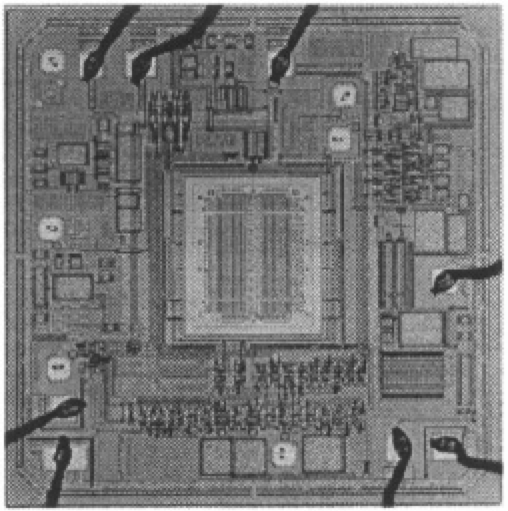
Q equal to $m\omega_o/b$

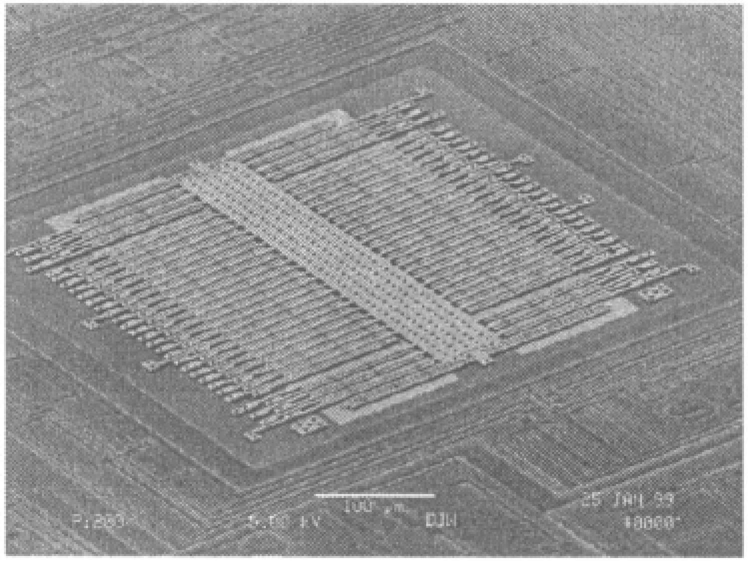
$$a_{n,\mathrm{rms}} = \sqrt{\frac{4k_B T\omega_o}{mQ}}$$

ADXL326 = 320ug/sqrt(Hz)

PCB = 0.4ug/sqrt(Hz)

In practice, the signal-to-noise ratio, and, hence, the achievable accelerometer sensitivity, is dominated by other effects: the noise contributed by the position-measuring circuit, especially its first stage of amplification; the need to build additional stiffness into the structure (raising its resonant frequency) to prevent either sticking of parts during fabrication or excess fragility; or residual calibration errors and drift problems. We now consider position measurement methods.





- Other important factors to consider are voltage supply (sensitivity and range) and application (power)