Vibration Measuring Instruments

Accelerometers

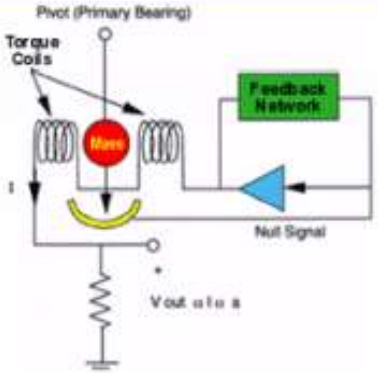
- 3 accelerometer types used in civil structures:

  ✓ Force balance accelerometers (FBA)
  - Greatest market share
  - Expensive at approximately $1000 per FBA

  ✓ Piezoelectric accelerometers
  - Popular in dynamic settings
  - Moderate pricing at approximately $400 per accelerometer

  ✓ Microelectromechanical system (MEMS)
  - Represents the future
  - Demand driven by car manufacturer
  - Small and accurate
  - Inexpensive $5-50 per accelerometer

Force Balance Accelerometer



Operating Principle

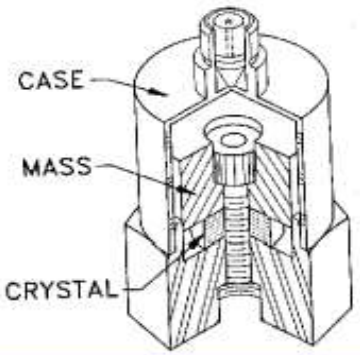
Kinemetrics EpiSensor

- Feedback current that balances internal mass is proportional to acceleration
- California Building Code (2001) requires at least 3 accelerometers (usually FBAs) installed in structures:
  - ✓ Floor areas greater than 5,500 m^2 or over 6 stories

Piezoelectric Accelerometer

- Piezoelectrics are a crystalline material that:
  - ✓ Generate current when strained
  - ✓ Strain when voltage is applied

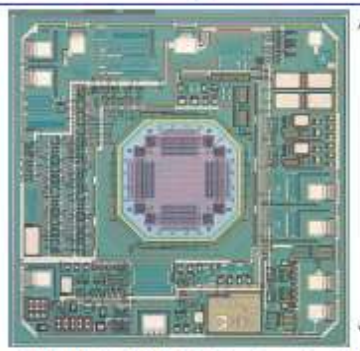
- Can be used with a proof mass to generate an electrical current proportional to acceleration
  - ✓ Can not sense static (DC) acceleration fields (gravity)



MEMS-Based Accelerometers

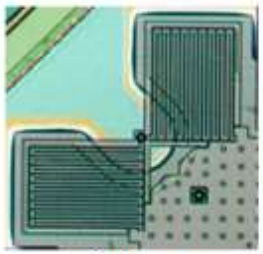
- **M**icro**e**lectro**m**echanical **s**ystem (MEMS) accelerometers
- Creation of mechanical structures only micrometers in size on silicon wafers (same process as CMOS integrated circuits)
- Cost advantage derived from using well developed CMOS fabrication process
- MEMS - more accurate and sensitive sensors in form factors and unit costs not previously possible
- Cost advantage of MEMS - integration of sensors and digital circuitry (like A/D conversion) all on one die
- Car industry (accelerometers for air bag deployment) has driven market demand
  - ✓ GM will only buy sensor when they are less than $5!

Analog Devices ADXL210

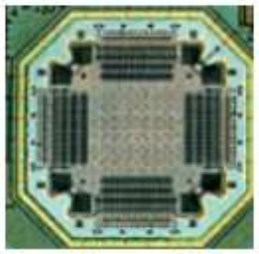


Completed ADXl210 Device in Silicon

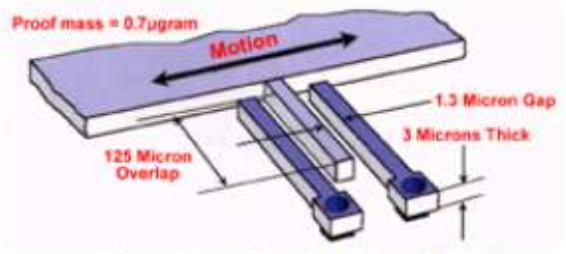
Packaged Device



Springs



Proof Mass = 0.7 μg



Capacitive Readout Mechanism

Analog Devices ADXL210

- Low cost, low power 2-axis accelerometer – 10 g
- Balanced differential capacitors measure acceleration of silicon proof mass
- Variable bandwidth and resolution
  - ✓ Frequency range 0 - 50 Hz (Bandwidth)
  - ✓ Noise floor 4 mg (Resolution)
  - ✓ Range of linearity (+/- 10g)
  - ✓ Dynamic Range (in dB):
    - DR(dB) = 20log(Max/Min) = 20log(10/4E-3) = 68 dB