

Vibration Measurement Sensors

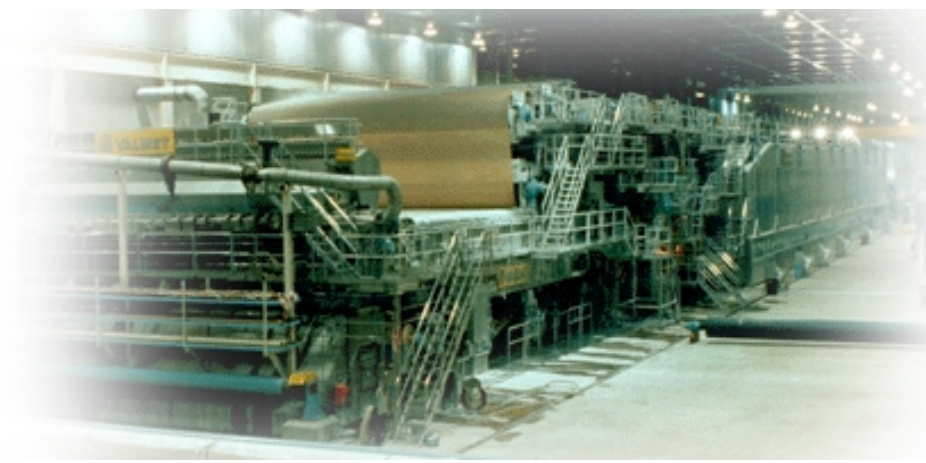
Who is Wilcoxon Research?

- Started in 1960 by engineers from United States Navy Research Laboratory
- Developed Accelerometers, Impedance Heads, and Reaction Shakers



Primary sales are to industrial customers

- Pulp & Paper
- Machine Tool
- Power Generation
- Petrochemical
- Food Processing
- Steel & Aluminum



Who is Wilcoxon Research

- Early Markets were Naval Engineering and Test for US, French, and British Navies
- Entered Condition Monitoring in the early 1980's with Palomar, Scientific Atlanta, and CSI

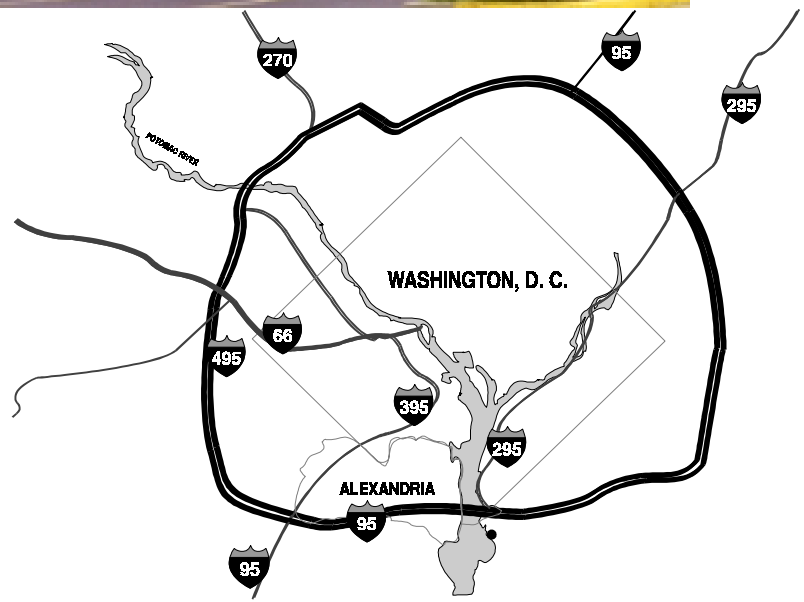




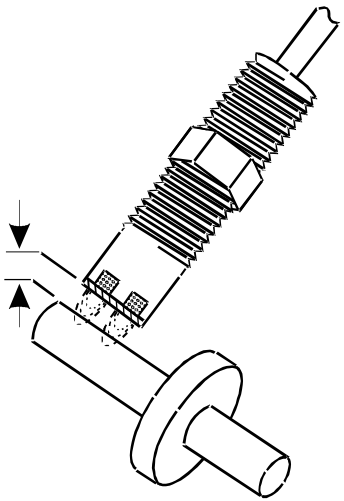
Wilcoxon Research Today



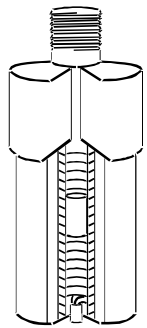
- Worlds largest manufacturer of industrial accelerometers
- Located in Metropolitan Washington DC along the I 270 Technology Corridor
- Approximately 120 employees



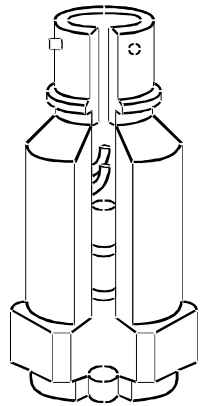
Basic Vibration Sensors



Noncontacting Displacement Transducer

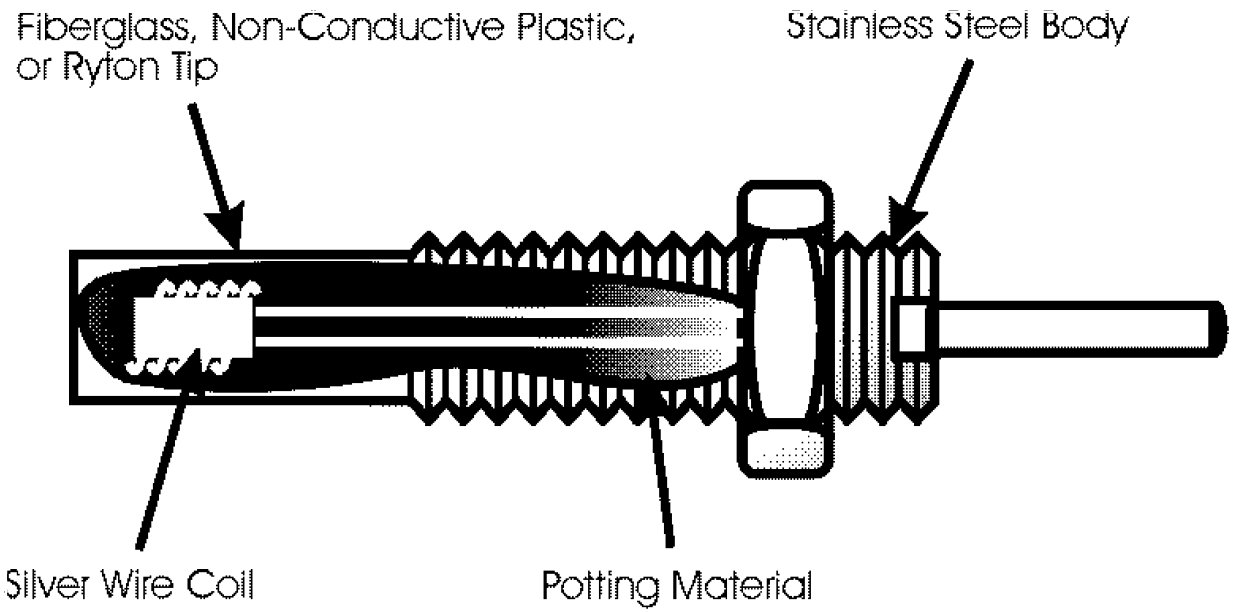


Electrodynamic Velocity Transducer



Accelerometer

Eddy Current Probe Fabrication



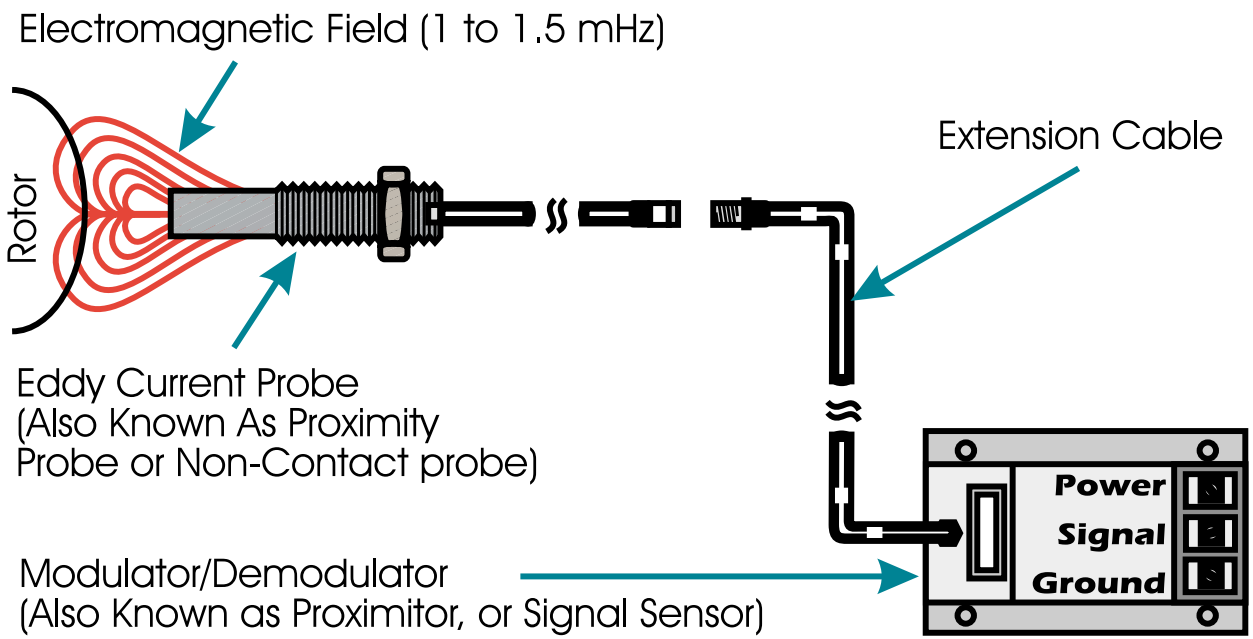
EP4403 - R1 8/92

Eddy Current Probe - How It Works

- Three matched components - Driver, probe and extension cable
- Voltage applied to the Driver causes an RF signal to be generated
- Signal is transmitted to the probe by the extension cable
- Coil inside probe tip serves as an antenna and radiates high frequency energy into free space
- Any conductive material within the field absorbs energy and causes output of probe to decrease proportional to gap distance

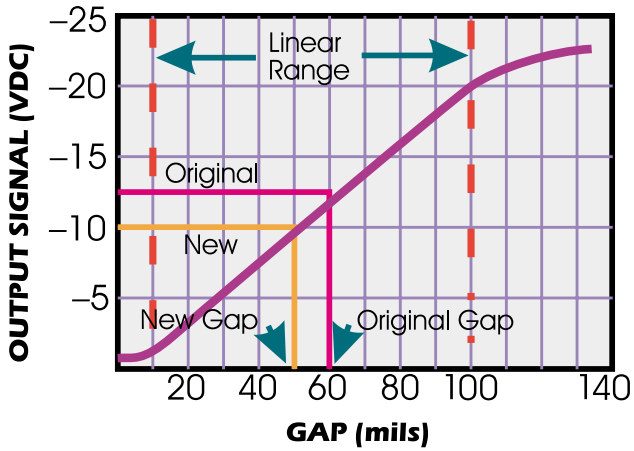
Eddy Current Probe

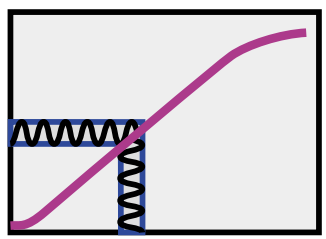
SYSTEM OVERVIEW



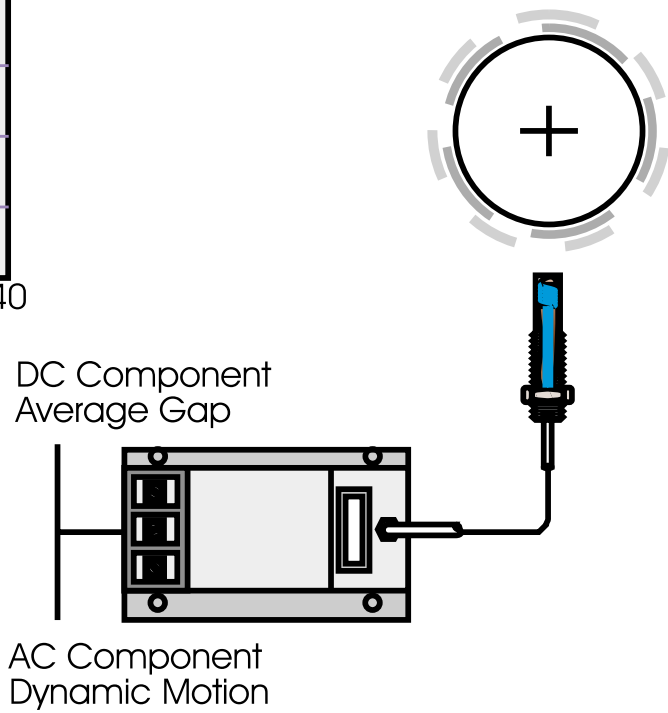
EP4402 - R1 8/92

SYSTEM RESPONSE





SIGNAL OUTPUT

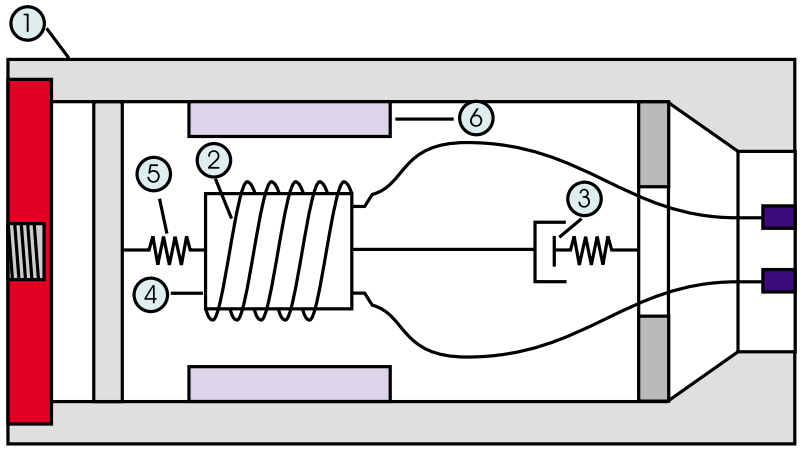


EP4406 - R1 8/92

Eddy Current Specifications

Calibrated Range	80 mils beginning at approx. 10 mils
Scale Factor	200mV/mil over a 80 mil range
Linearity	200 mV/mil straight line +/- 0.8 mils
Frequency Response	0 to 600,000 CPM (Theoretical)
Temperature Range	Driver -60 F to +212 F Probe and Cable -30 F to +350 F
Relative Humidity	to 95% noncondensing

Fabrication of Electrodynamic Velocity Sensor



1. Pickup Case
2. Wire Coil
3. Damper
4. Mass
5. Spring
6. Magnet

VL3002 - R1 8/92

- Housing vibrates while the spring-suspended coil remains stationary
- Amplitude of the output voltage is proportional to the velocity of the vibration

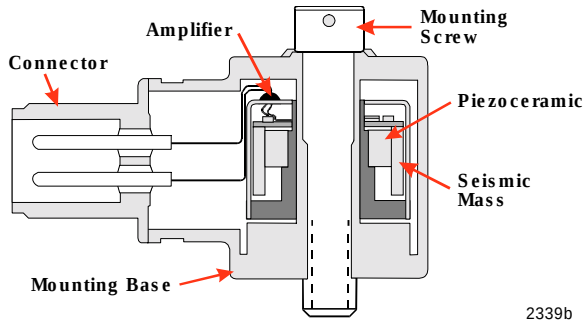
Types of Accelerometers

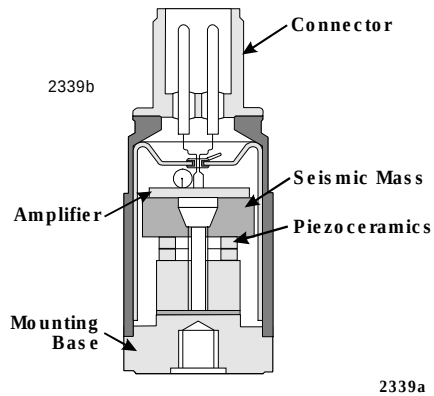
- Piezoelectric
  - Charge mode
  - Internally amplified
- Strain Gauge
- Piezoresistive
- Variable Capacitance
- Others

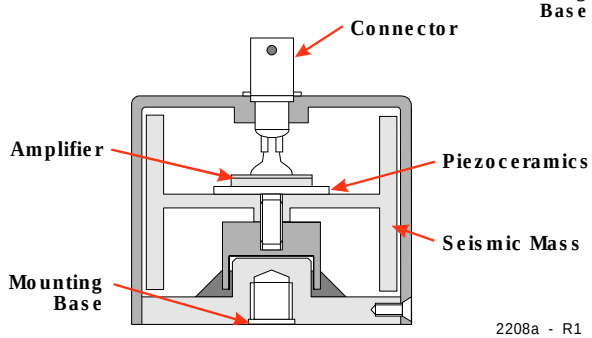


Piezoelectric Accelerometers

- Measures Acceleration
- Velocity or Displacement Output Available
- Very Sensitive
- Contacting
- Measures Absolute Casing Motion
- Measures Very Low Frequency
- Measures Very High Frequency

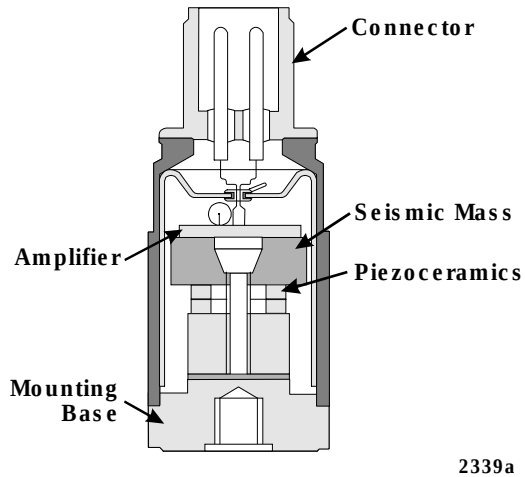




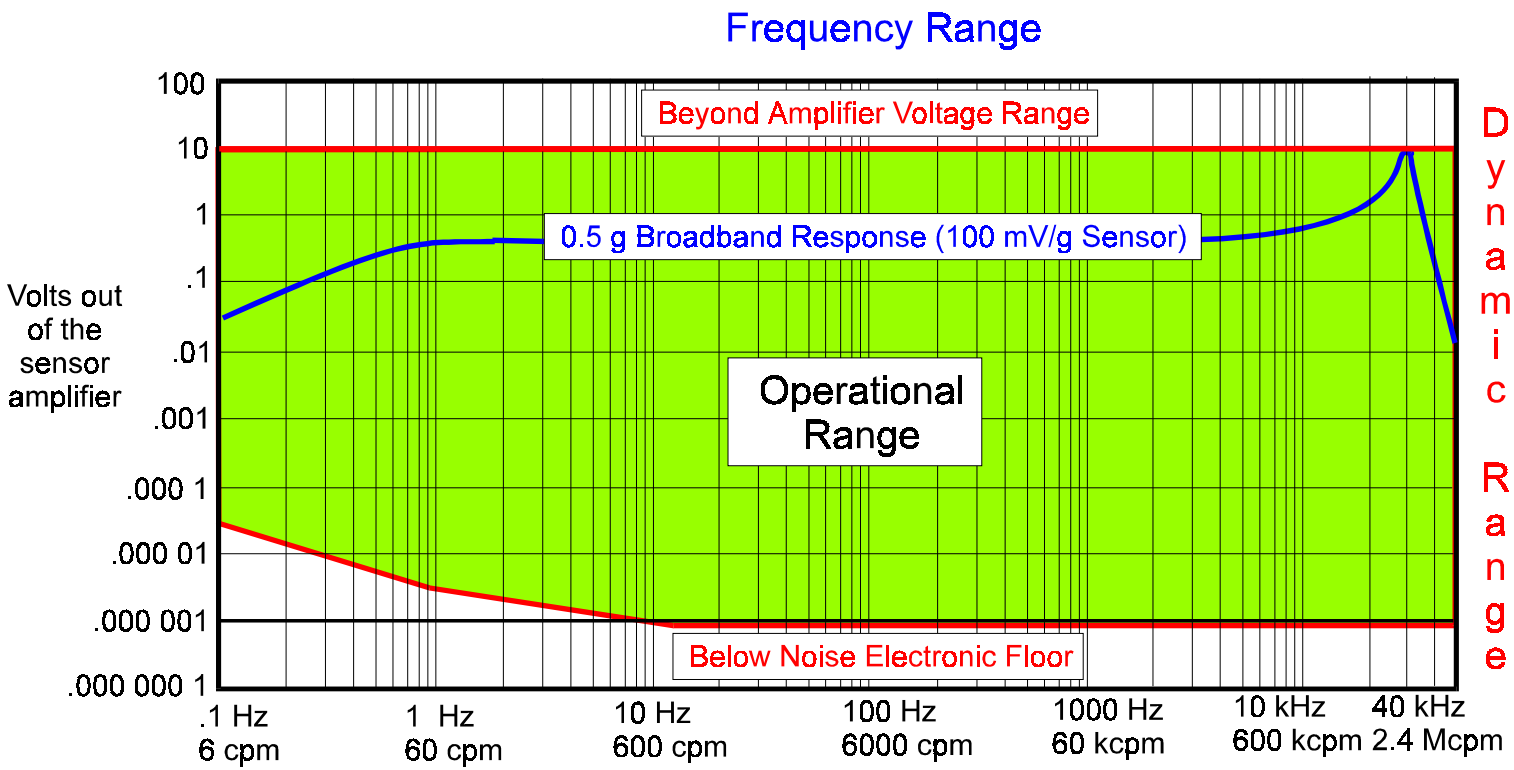


Piezoelectric Accelerometer - How It Works

- Piezoelectric material (sensing element) is placed under load using a mass
- As ‘stack’ vibrates, crystal is squeezed or released
- Charge output is proportional to the force (and acceleration)
- Electronics convert charge output into voltage output

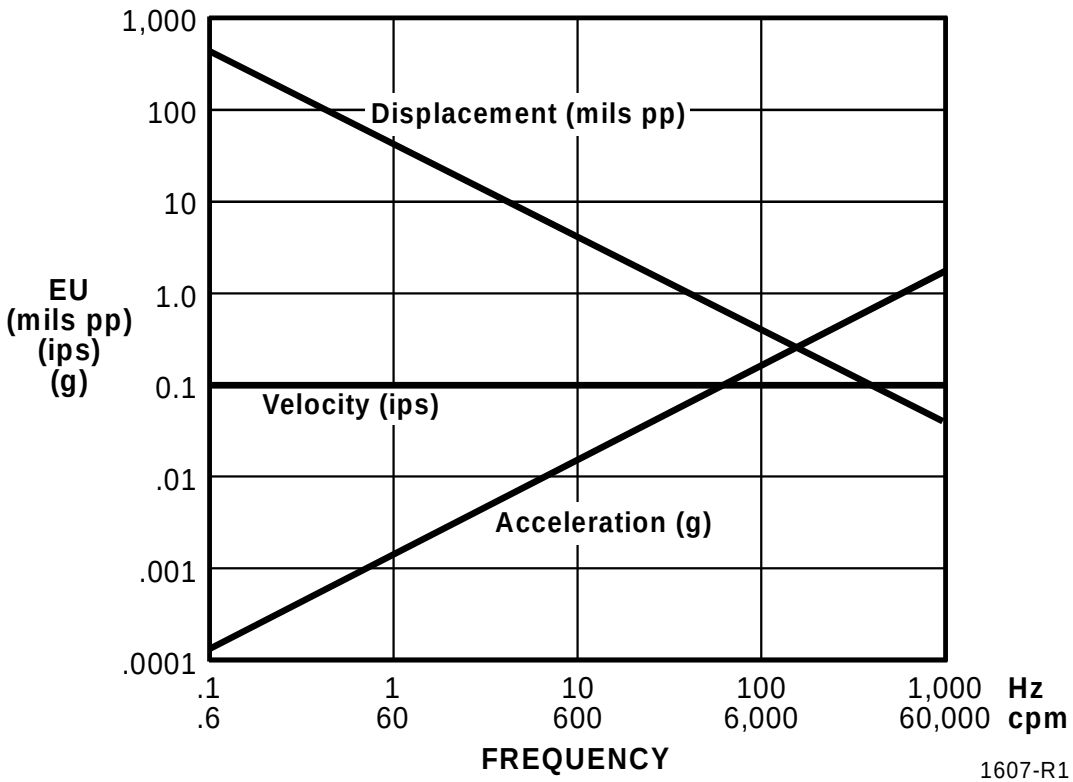


Operational Range



Operational Range of an Accelerometer Amplifier
(Shaded Region)

Vibration vs. Frequency

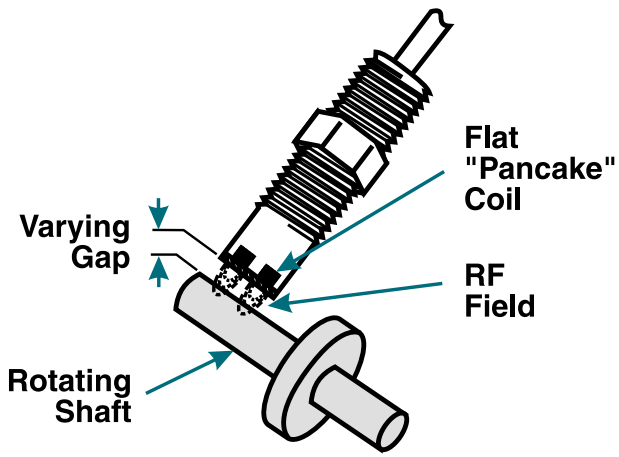


- Very Little Vibration Amplitude in terms of Acceleration is Produced at Low Frequencies
- Much Larger Amplitudes are produced in terms of Displacement

Eddy Probe

Advantages

- Low frequency response (to 0 Hz)
- Can measure relative displacement
- Useful as a key phasor for dynamic balancing & analysis
- Reliable if property installed and maintained



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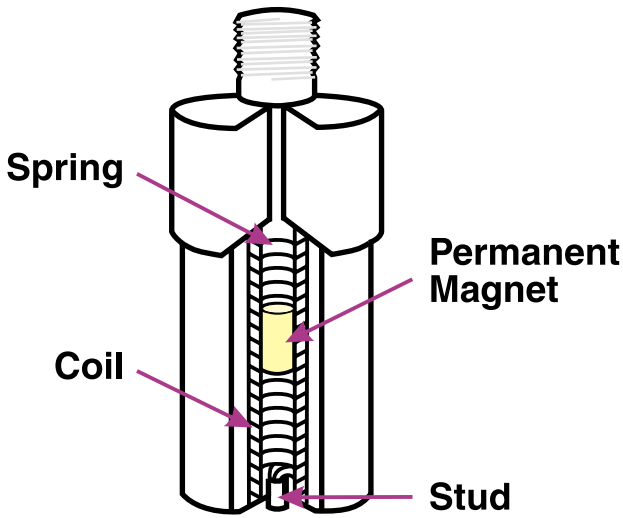
Disadvantages

- Difficult to install
- Practical limits of high frequency displacement measurement
- Calibration dependent on shaft material
- Shaft runout / glitch produces false signals

Electrodynamic Velocity Transducer

Advantages

- No external powering
- Powerful signal Output
- Easy to use (not as sensitive to mounting problems as alternative)
- Ability to operate at elevated temperatures



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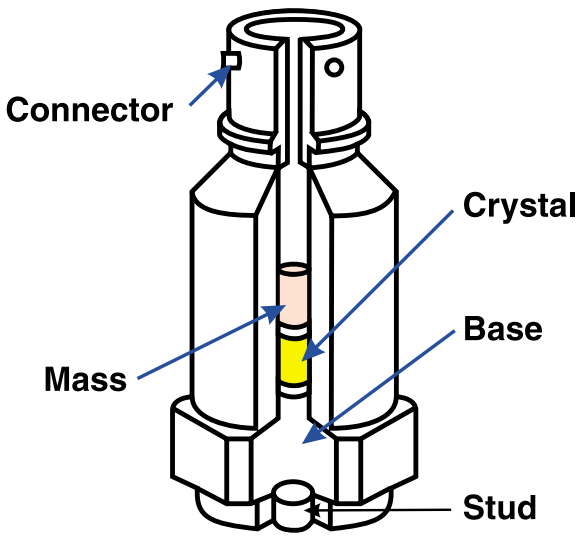
Disadvantages

- Not useful for very low frequency
- Not useful for very high frequency
- Moving parts wear
- Mounting orientation may be important
- Size
- Accuracy (resolution / noise as compared to alternatives)

Internally Amplified Accelerometer

Advantages

- Very wide frequency
- Wide amplitude range
- Broad temperature range
- Velocity or displacement output available
- Rugged, industrial design



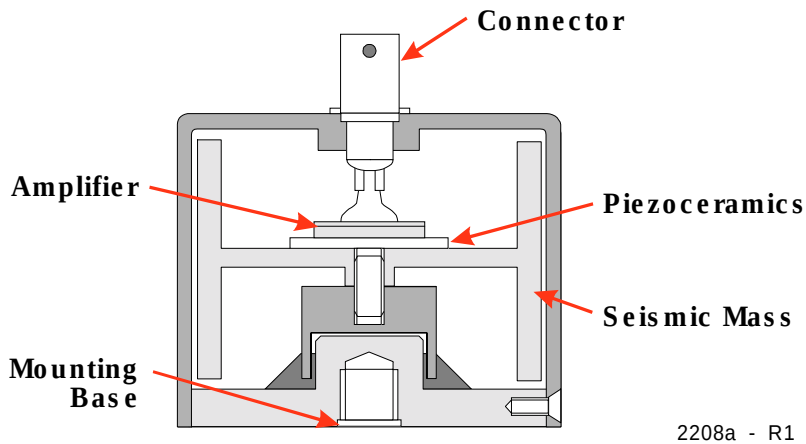
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Disadvantages

- Not responsive to 0 Hz
- Internal Amplifier limits temperature

Low Frequency Accelerometer Considerations

- High Sensitivity
- Low Noise
- Low Pass Filter
- Environmental Protection
  - Overload Protected
  - Resists Thermal transients
  - Low Strain Sensitivity
- Limited Amplitude Range



Sensitivity Selection

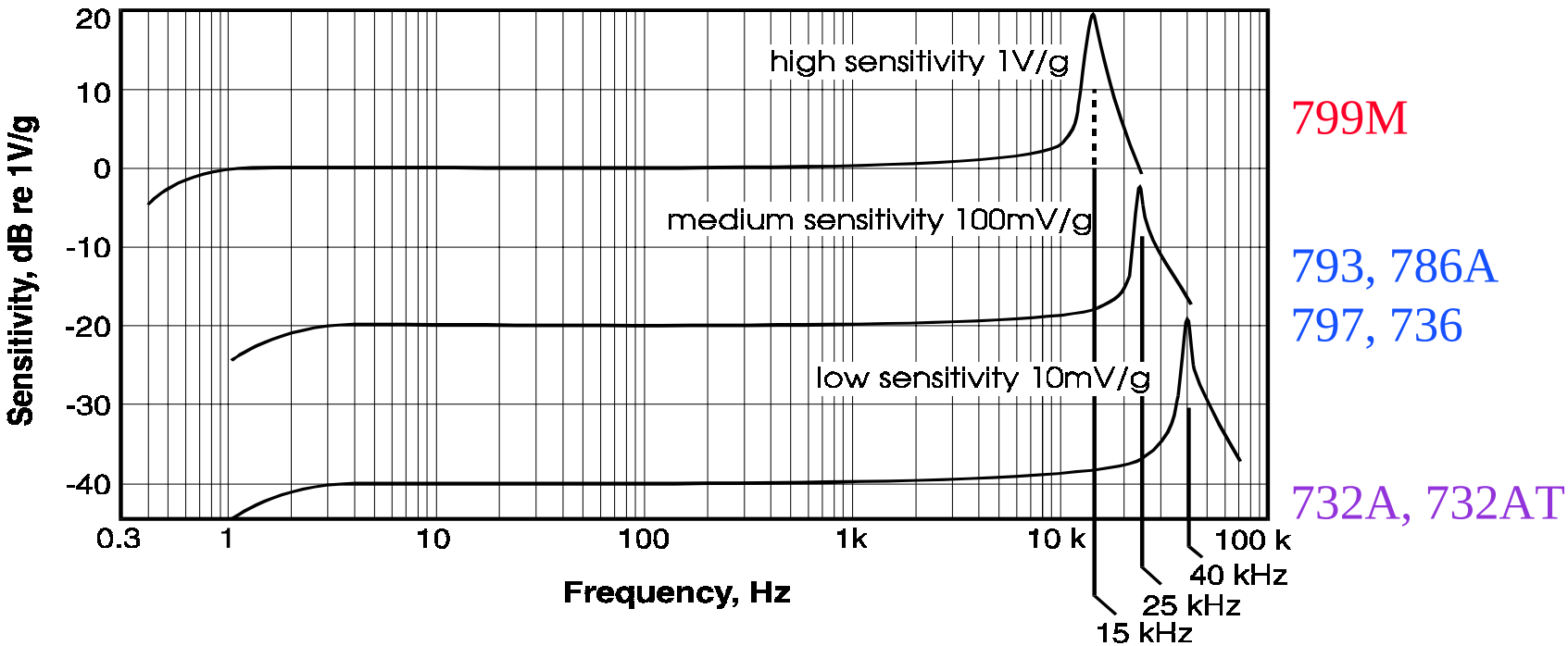
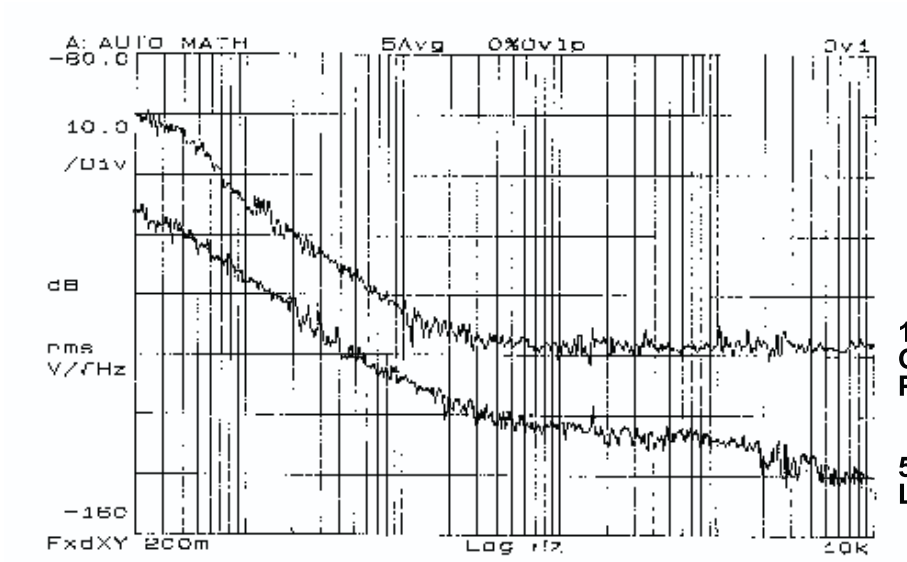


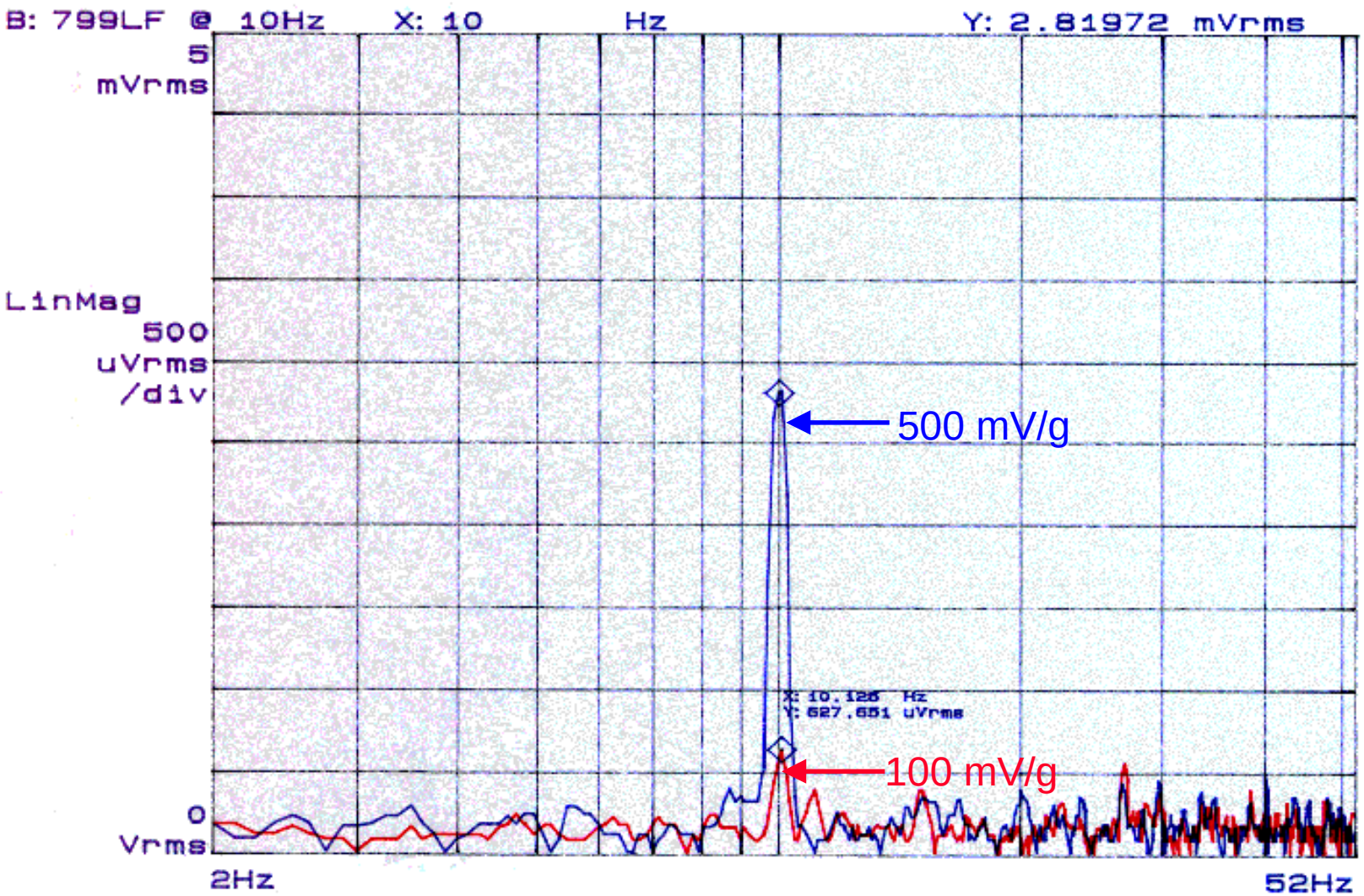
Figure 2. Typical Frequency Response Curves for Various Sensitivities

Electronic Sensor Noise

- Sets the Absolute Measurement Floor
- Increases as Frequency Decreases
- Dependent on Charge Sensitivity



PZT Piezoceramics are very sensitive and must be used for Low Frequency Accelerometers


B: 799LF @ 10Hz
X: 10 Hz
Y: 2.81972 mVrms
5
mVrms
LinMag
500
uVrms
/div
0
Vrms
2Hz
52Hz
500 mV/g
100 mV/g
X: 10.128 Hz
Y: 627.651 uVrms

Electronic Sensor Noise

- Electronic Sensor Noise can be Improved by using more Lines of Resolution
- The Cost is greater Measurement Time
- Data Acquisition Time = Lines/Fmax

Lines of Resolution	400	800	1600	3200	3200
Electronic Spectral Noise of a Low Frequency Sensor (1 µg/⊠Hz)	0.16 µg	0.11 µg	0.79 µg	0.056 µg	
Measurement Time Per Data Set	40 sec	80 sec	160 sec	320 sec	(5.3 min)
Measurement Time for Four (4) Averages Without Overlapping	160 sec	320 sec	640 sec	1,280 sec	(21.3 min)
Measurement Time for Eight (8) Averages Without Overlapping	320 sec	640 sec	1,280 sec	2,560 sec	(42.7 min)

2348a - R1

Summary of Concepts

Reminder - very little motion in terms of acceleration is produced at low frequencies

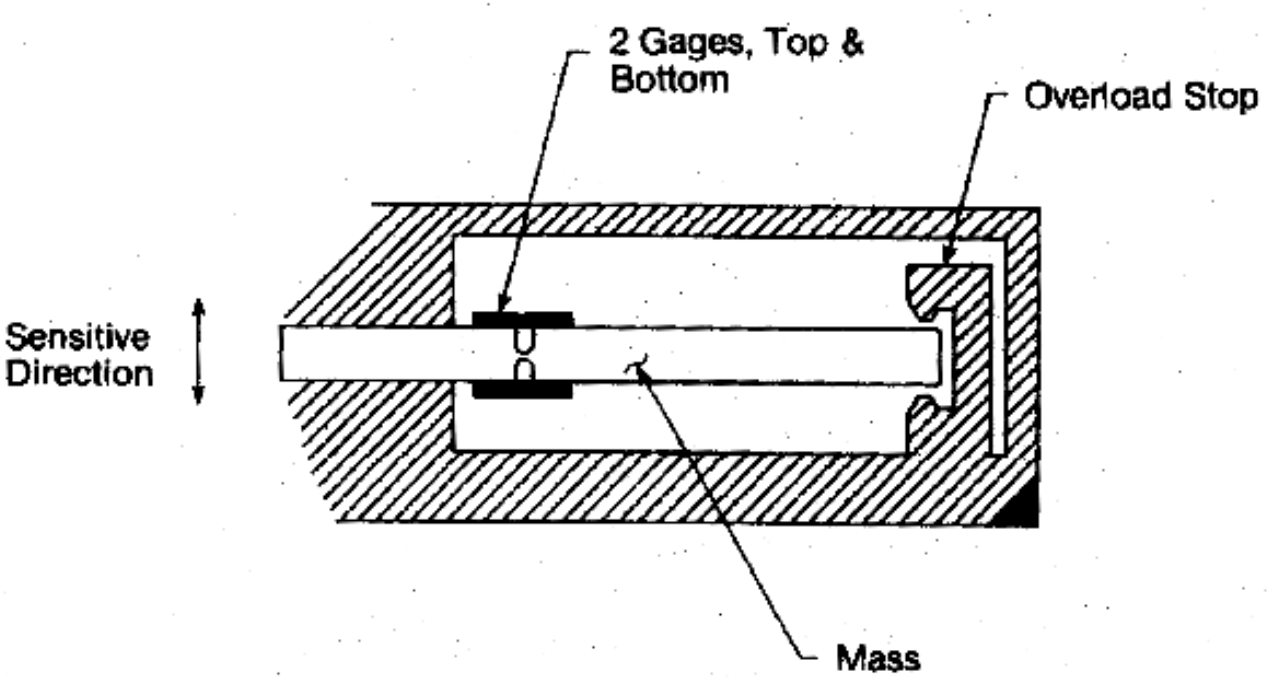
	1.5 Hz (90 cpm)	10 Hz (600 cpm)	100 Hz (6,000 cpm)	1,000 Hz (60,000 cpm)	10,000 Hz (600,000 cpm)
Displacement (mils)	32	5	.5	.05	.005
Velocity (ips)	.3	.3	.3	.3	.3
Acceleration (g)	.007	.05	.5	5	50
100 mV/g Accelerometer (V)	.0007	.005	.05	.5	5
500 mV/g Accelerometer (V)	.0035	.025	.25	2.5	25
100mV/ips PiezoVelocity Transducer (V)	.03	.03	.03	.03	.03

2342a_R2.dt1

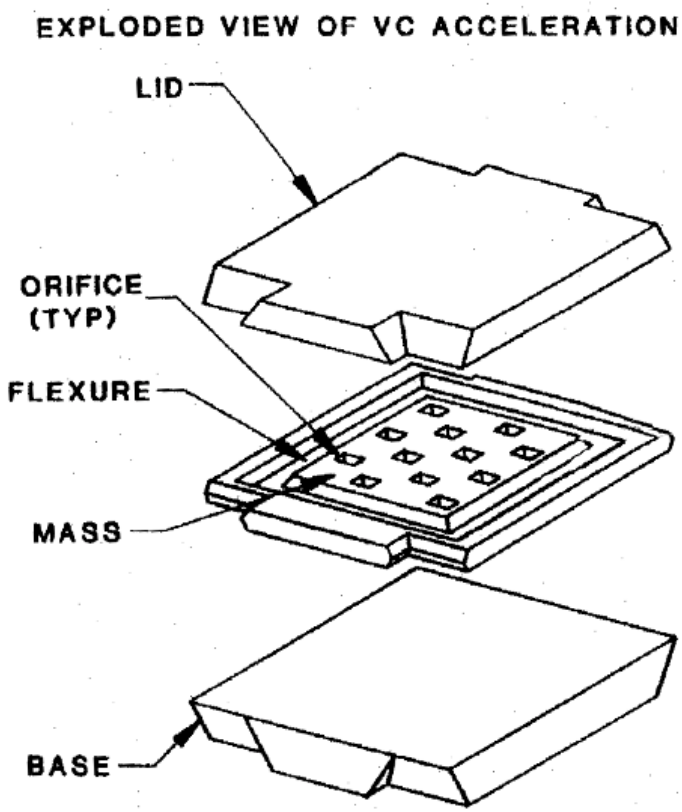
Strain Gage Accelerometers

- Metal (wire or foil) strain gages on a beam or diaphragm structure
- Measure strain caused by inertial forces on mass
- Low sensitivity and/or low natural frequency
- Rarely used; being replaced by PR and VC

Piezoresistive Accelerometers



Variable Capacitance



An exploded view of a variable capacitance acceleration sensor shows the primary elements in this assembly.

Servo Force Balance

