Vibration Measurement

Vibration Measurement

- **Vibration** is a physical movement & oscillation of a mechanical part about a reference point
- Mostly vibrations are sinusoidal displacement in nature about its **mean position**
- Vibration measuring devices having mass, spring, *etc.* are called ***seismic instruments***
- Vibratory response can be expressed through a number of parameters: It can be defined by specifying its **frequency**, its amplitude or **maximum velocity** or maximum acceleration

Nature of Vibrations

For sinusoidal vibration,

Displacement $x = x_m \sin \omega t$

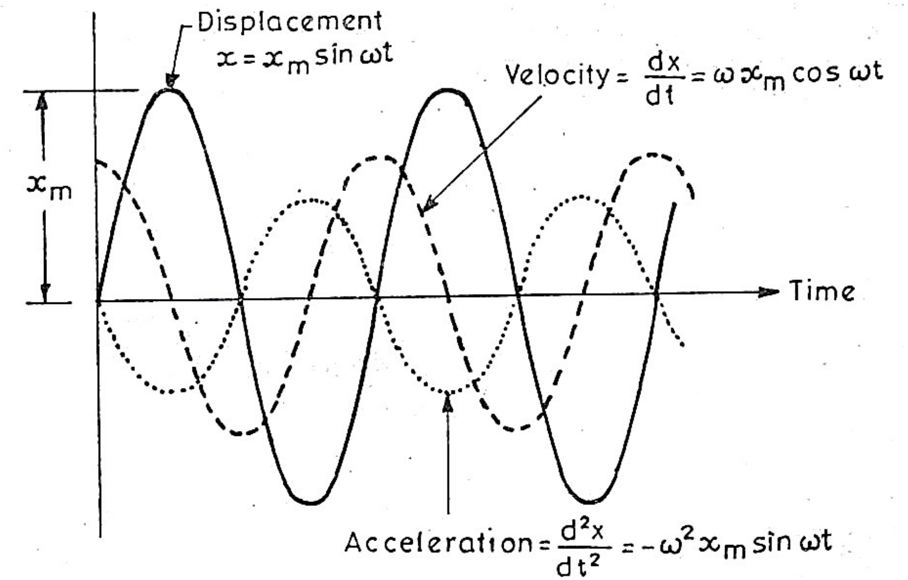
x_m= amplitude, ω = angular frequency

Velocity $v = \dot{x} = x_m \omega \cos \omega t$

maximum velocity $v_0 = x_m \omega$

Acceleration $a = \ddot{x} = -x_m \omega^2 \sin \omega t$

maximum acceleration $a_0 = -x_m \omega^2$



Quantities involved in Vibration Measurements

TWO WAYS FOR MEASUREMENT OF ACCELERATION

- Measuring either displacement or velocity and then taking their derivatives to obtain the value of acceleration. Here acceleration is measured indirectly

- Measuring the acceleration directly

Hence two types of Instruments

- **VIBROMETERS & ACCELEROMETERS**

Vibrometers and Accelerometers

- **A vibration pickup** or vibrometers is An instrument which yield an O/P that is either proportional to displacement or velocity.

- **An accelerometer** is a pickup whose O/P is a **function of acceleration**

- One of the most sensitive vibration detectors is human touch

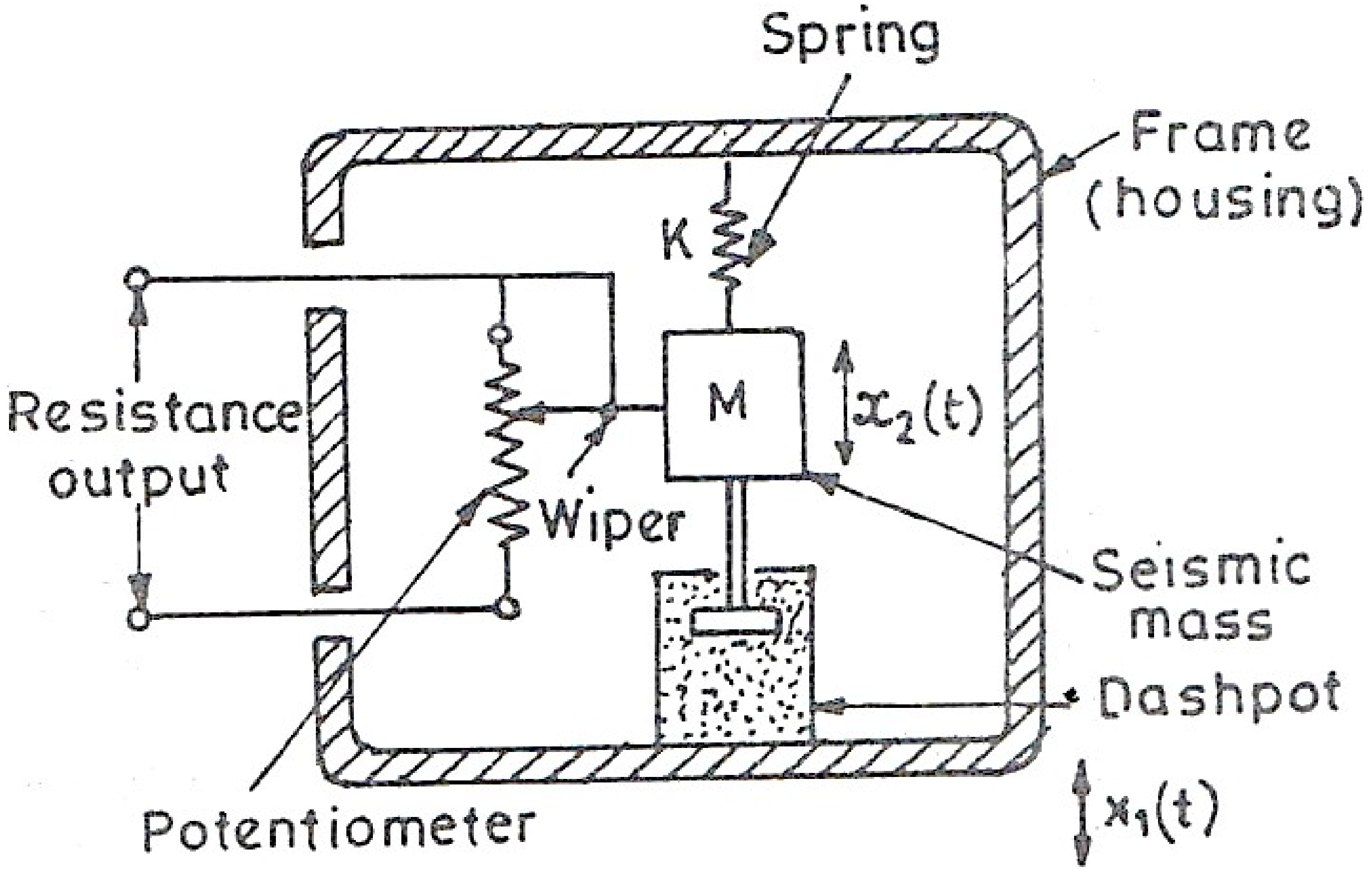
- An average human being can detect sinusoidal vibrations having an amplitude as low as **0.3 micrometer**

Types of Accelerometer

Potentiometric Type
LVDT
Variable Reluctance
Strain Gauge
Piezoelectric

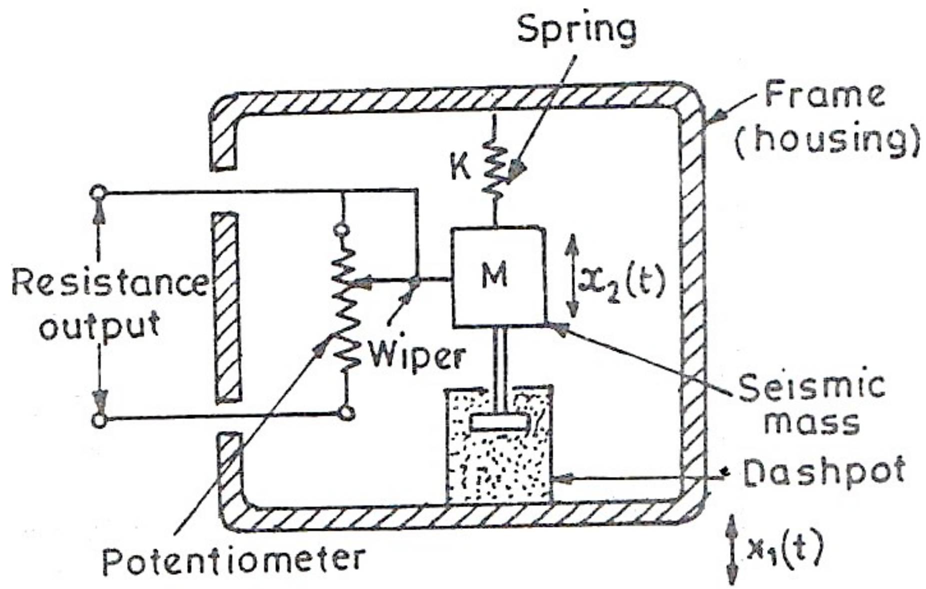
Potentiometric type Accelerometer

Potentiometric Type Accelerometer



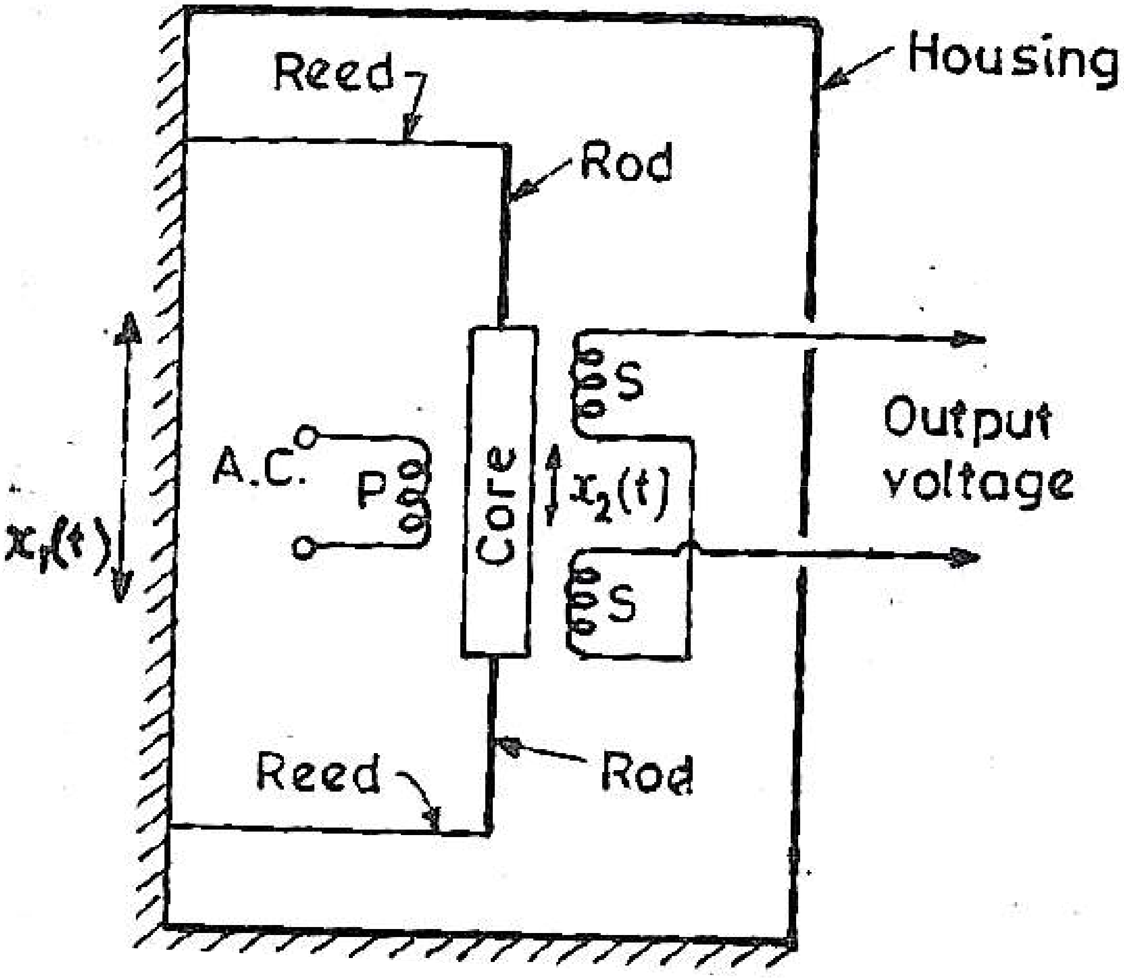
Potentiometric type Accelerometer

- **Seismic mass** is attached to **wiper arm** of **resistance potentiometer.**
- **Relative motion of mass w.r.t. transducer frame is sensed either as change in resistance or as change in voltage O/P.**
- **Damping** may be provided by filling housing of accelerometer completely with a viscous fluid or it may be provided by a dashpot.
- **Proper damping is necessary because it increases the range of frequencies over which transducer may be used**
- **Drawback**
  - limited resolution



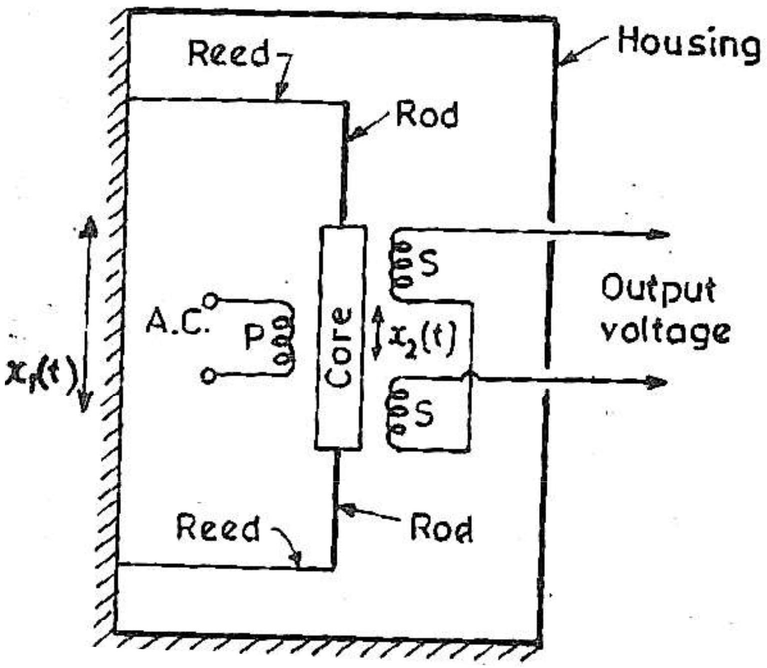
LVDT type Accelerometer

LVDT Accelerometers



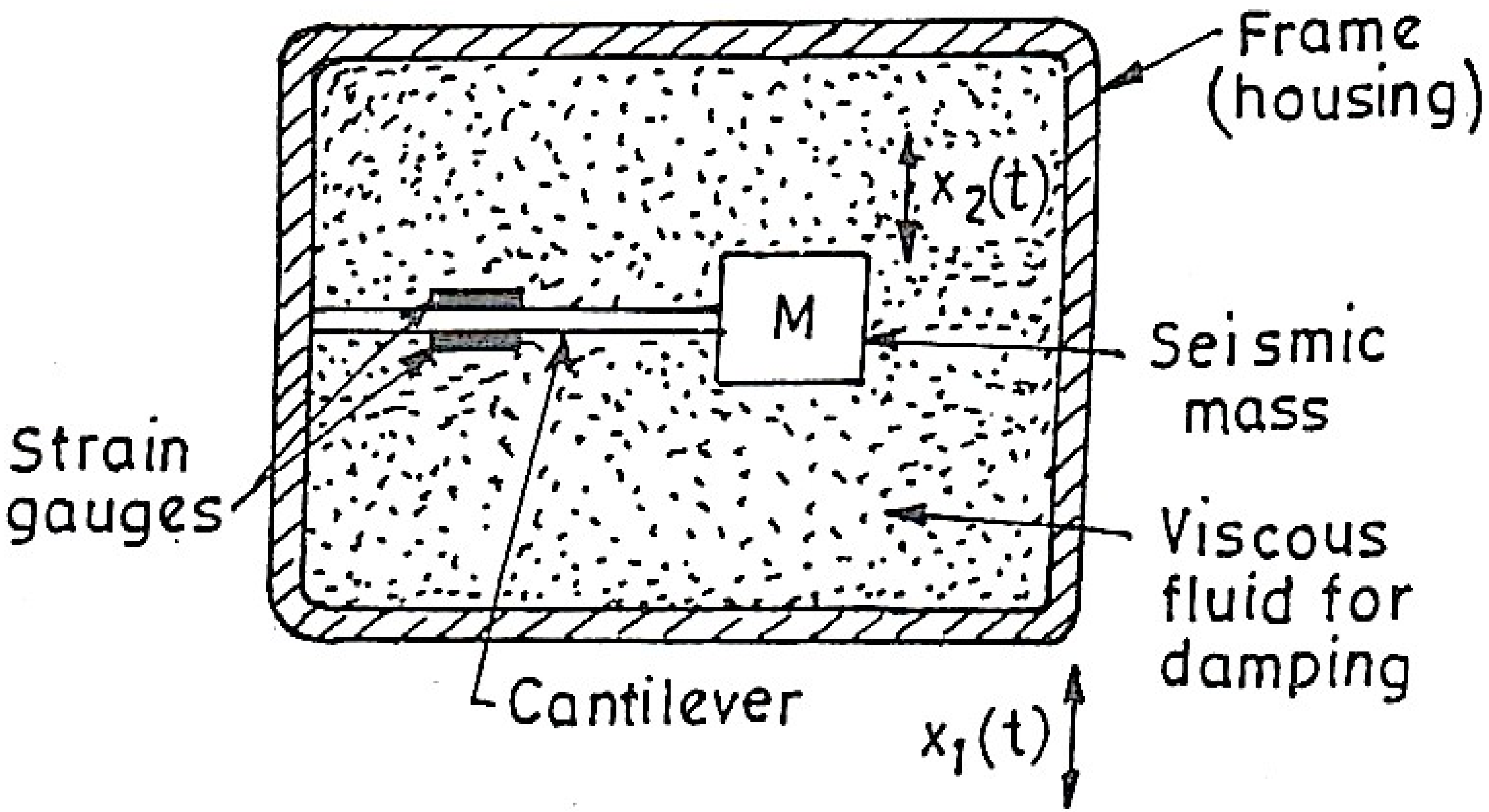
LVDT type Accelerometer

- **Core of LVDT** acts as **mass** and two flexible reeds, attached at each end of rods of core, provide necessary **spring action.**
- Reeds are attached to a housing which is subject to vibrations.
- **As sensor moves up and down on account of vibrations, LVDT secondaries give an a.c. O/P voltage.**
- Magnitude of this O/P signal depends upon amplitude of vibrations
- **Advantages**: smaller mass, higher natural frequency, lower resistance to the motion, contactless device



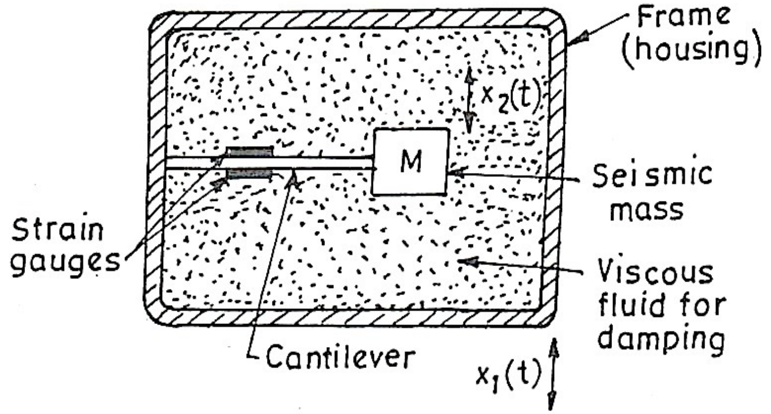
Strain Gauge Accelerometer

Strain Gauge Accelerometers



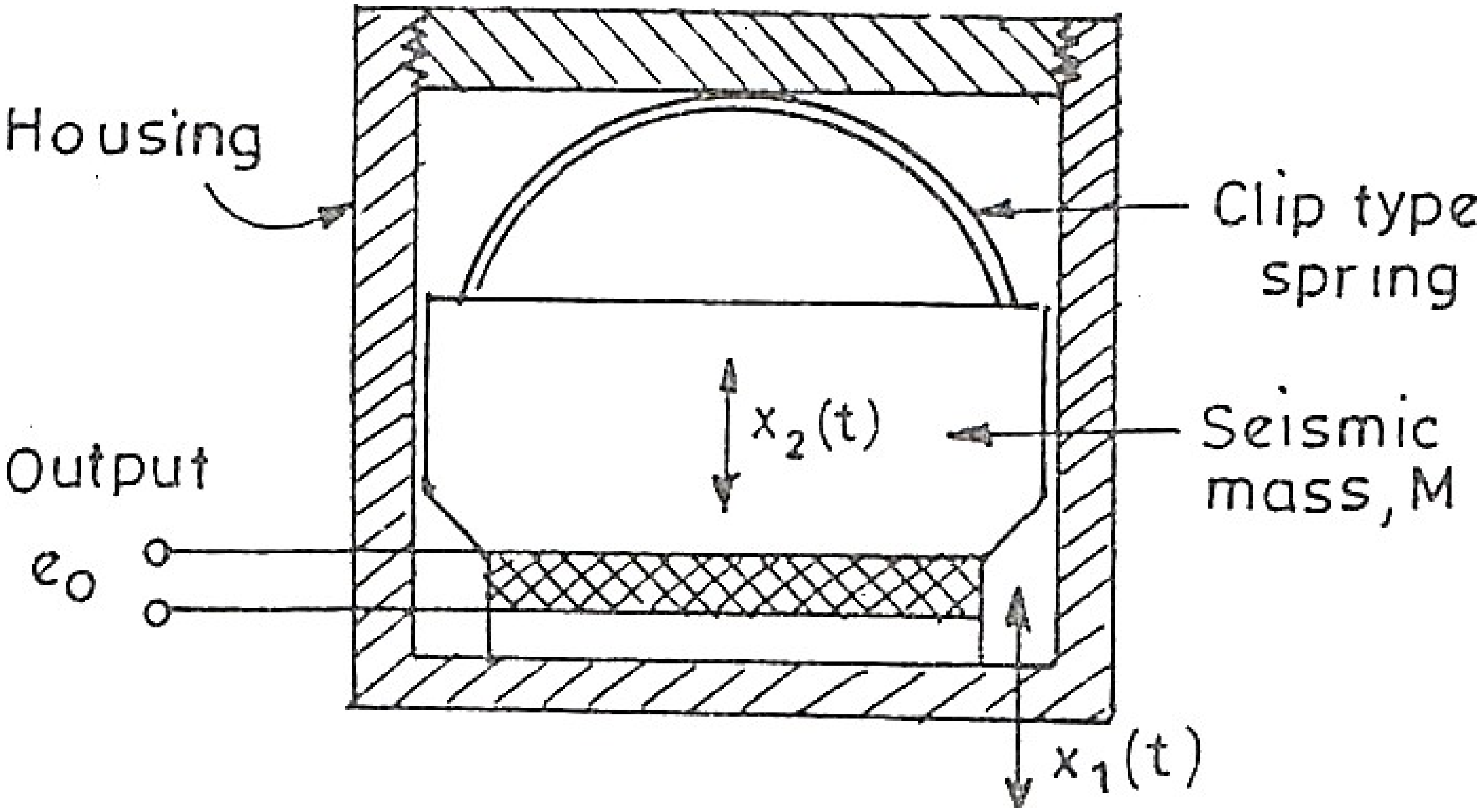
Strain Gauge Accelerometer

- Seismic mass is mounted on a cantilever beam
- A strain gauge is mounted on each side of cantilever beam to sense the strain in beam resulting from vibrational displacement of mass
- Damping is provided by filling housing with a viscous fluid
- **Strain gauges is connected to appropriate wheatstone circuit, whose O/P indicates relative displacement of mass w.r.t. housing frame**
- **Advantage**: more sensitive then piezo-eleletric, can be used for small acceleration measurement



Piezoelectric Accelerometer

Piezoelectric Accelerometers



Piezoelectric Accelerometer

- When **force F** is applied to **piezoelectric crystal** it develops a charge $\boldsymbol{Q = dF}$ coulomb where d = charge sensitivity of crystal; C/N.

- With varying acceleration to mass-crystal assembly crystal experiences a varying force

Force $\boldsymbol{F = m \times a}$

- Force generated a varying change $Q = dF = dMa$

- Suppose crystal has capacitance C, no load output voltage is

$$e_0 = \frac{Q}{C} = \frac{dF}{C} = d\frac{Ma}{C}$$

- Therefore output voltage is measure of acceleration