



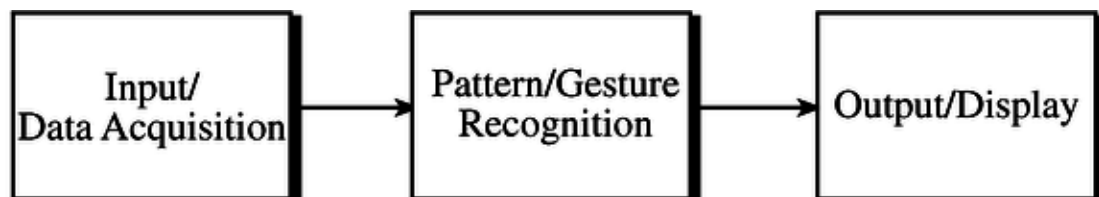
Input/Data Acquisition System Design for Human/Computer Interfacing

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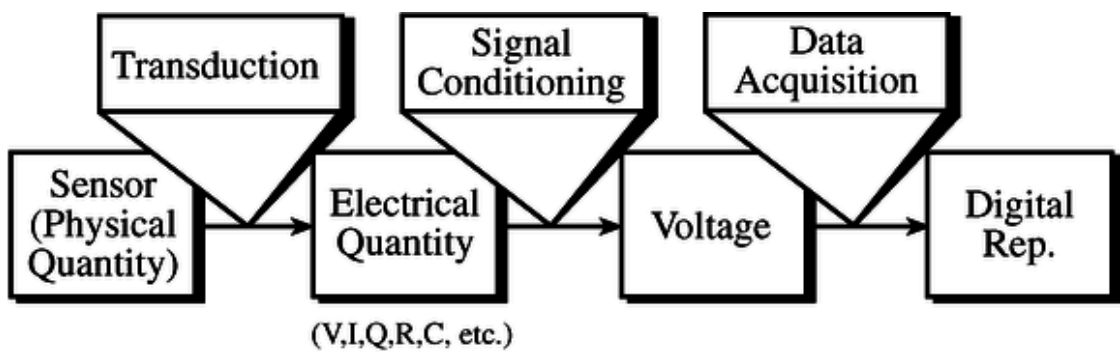
Introduction



Overview

- Introduction
- Sensors
- Signal Conditioning
- Data Acquisition
- System Integration

Introduction





Overview of Sensor Issues

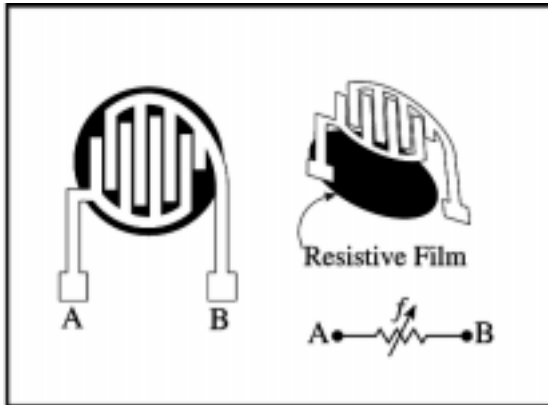
- Corresponding to Our Senses or Our “Outputs”?
- Categorize According to:
 - ◆ Physics of Operation - Photoelectric Effect
 - ◆ Phenomenon Measured - Hand Motion
 - ◆ Application - Cursor Control
- Important Signal Properties:
 - ◆ Dynamic Range / Sensitivity
 - ◆ Temporal Dynamics
 - ◆ Frequency Structure



Sensors

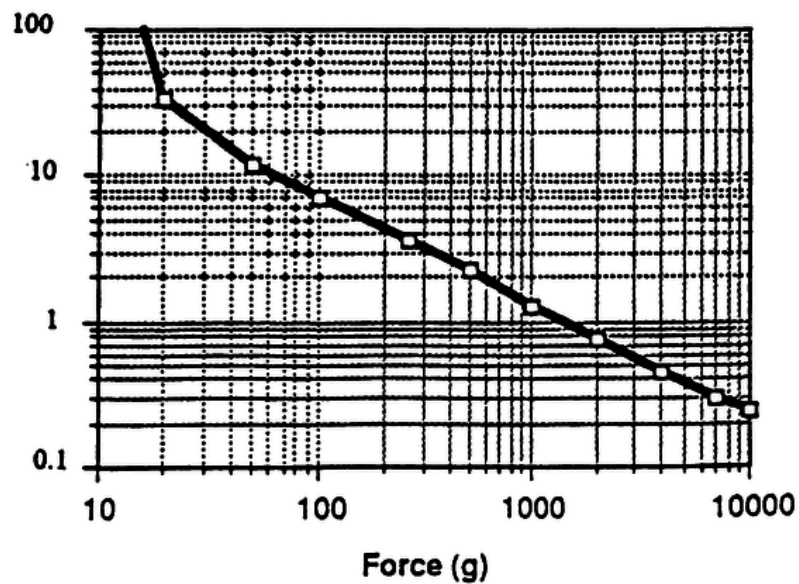
- Force Sensing Resistor (FSR)
- Piezoelectric Sensor
- Accelerometer
- Bioelectric Sensor

Force Sensing Resistor



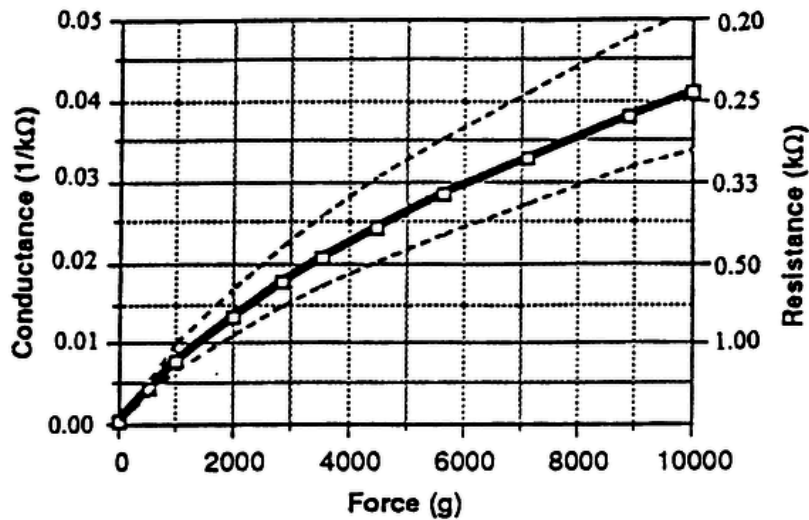
- Resistive Film
- Interdigitating contacts
- Resistance inversely proportional to force
- Conductance proportional to force

Force Sensing Resistor



- Force versus Resistance

Force Sensing Resistor

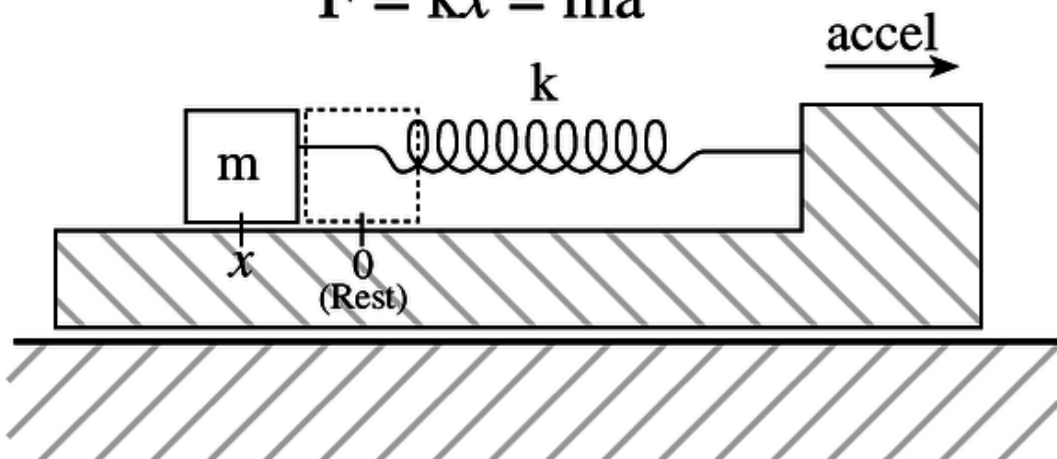


- Conductance versus Force
- Does not give accurate measurements

Accelerometer

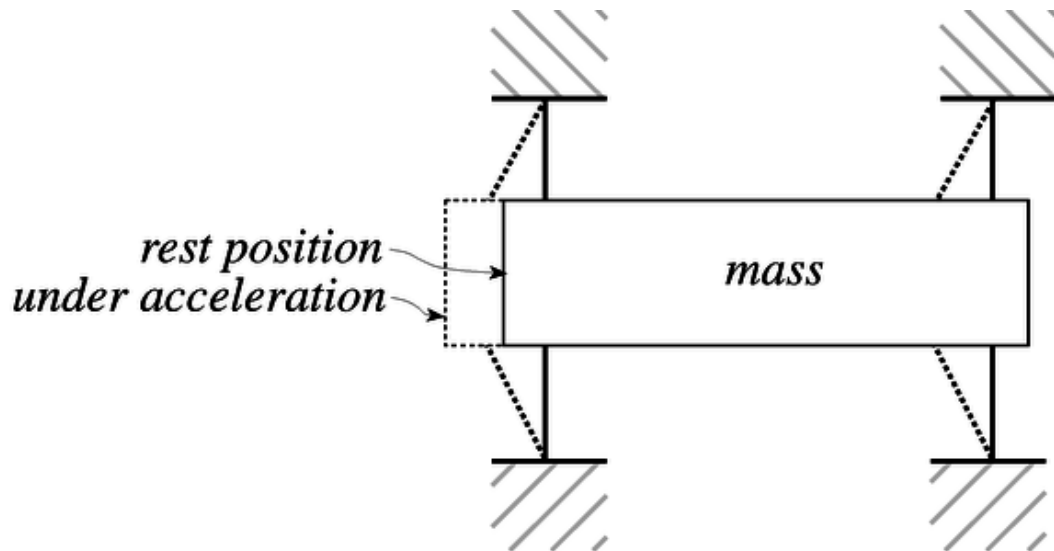
- Can measure acceleration by measuring the displacement

$$F = kx = ma$$



Analog Devices ADXL50

■ Micromachined mass-spring system



Analog Devices ADXL50

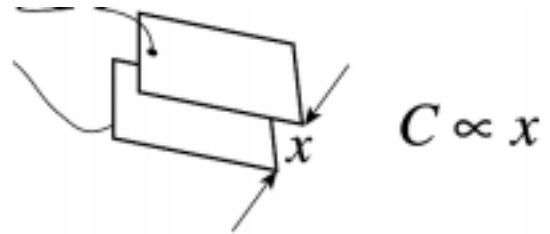
■ Need to measure the displacement of the mass

■ The ADXL50 uses the principle of electrical capacitance

- ◆ Capacitance is proportional to distance
- ◆ By measuring the capacitance, one can measure the distance

ADXL50 Accelerometer

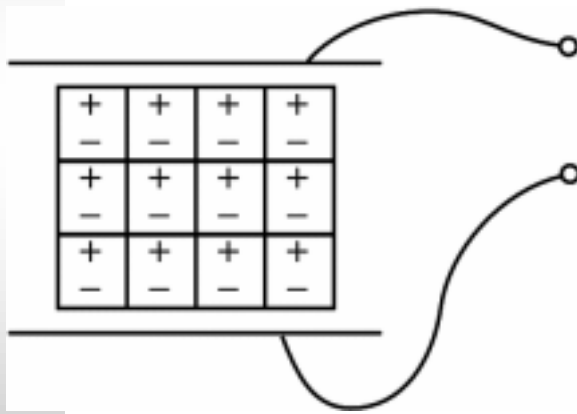
- Parallel conductive plates
- Capacitance is proportional to the distance between the plates



Piezoelectric Sensor

- Electrically polarized material
- An applied force deforms the material
 - ◆ creates an excess of surface charge
- Useful for many things:
 - ◆ force
 - ◆ microphone / speaker
 - ◆ acceleration
 - ◆ temperature

Piezoelectric Sensor



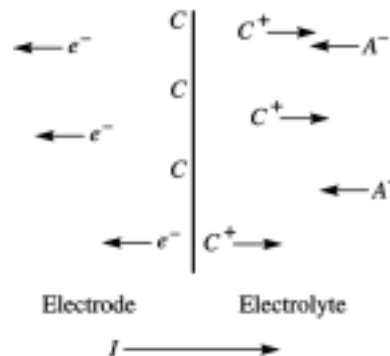
- Form a capacitor
- $V=Q/C$
 - ◆ proportional to charge (Q)
- An applied force will result in excess charge

Microphones

- Carbon
 - ◆ Uses resistance
- Condenser
 - ◆ Uses capacitance
- Piezoelectric
 - ◆ piezoelectric effect
- Magnetic
 - ◆ electromagnetics

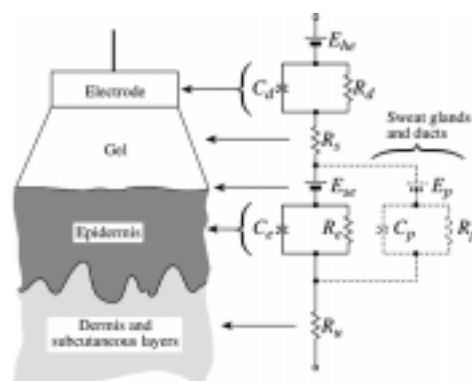
Surface Electrodes - What Are They?

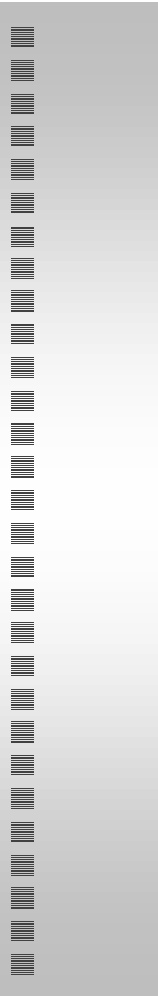
- Nervous System Involves the Flow of Ions
- Electrode/Electrolyte Changes Ionic Flow to Flow of Charge



Surface Electrodes - Common Choice

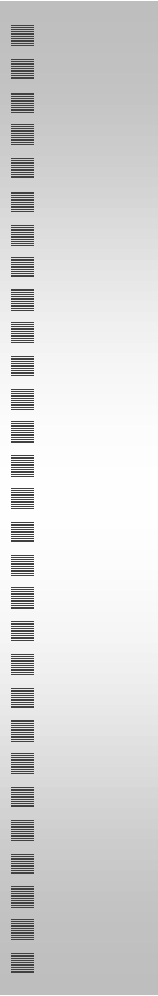
- Most Common Ag-AgCl
 - ◆ Nonpolarizable
 - ◆ Lower Impedance
 - ◆ Lower Noise ($\ll 10\mu\text{V}$)





Surface Electrodes - What do They Measure?

- Muscle Tension (EMG)
- Brain Activity (EEG)
- Eye Movement (EOG)
- Heart Activity (EKG)



Introduction to Signal Conditioning

- Requirements for Analog to Digital Convertor (ADC) Input
 - ◆ Voltage Waveform
 - ◆ Maximize Dynamic Range ($\pm V_{ref}$)
 - ◆ Decrease Source Impedance
 - ◆ Limit Bandwidth

Introduction to Signal Conditioning

■ Additional Requirements

- ◆ Signal Isolation
- ◆ Signal Preprocessing
 - ◆ Thresholding
 - ◆ Energy Measurement
- ◆ Removal of Unwanted Signals

The Non-Inverting Amplifier

■ Gain $A_v = 1 + \frac{R_1}{R_2}$

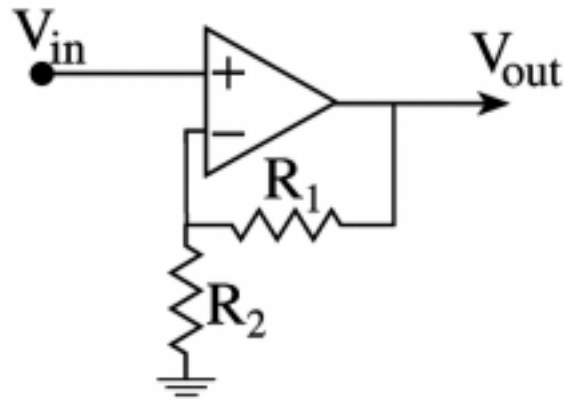
■ Input Impedance

$$R_{in} = \infty \Omega$$

■ Output Impedance

$$R_{out} = 0 \Omega$$

The Non-Inverting Amplifier



The Inverting Amplifier

■ Gain $A_v = -\frac{R_F}{R_I}$

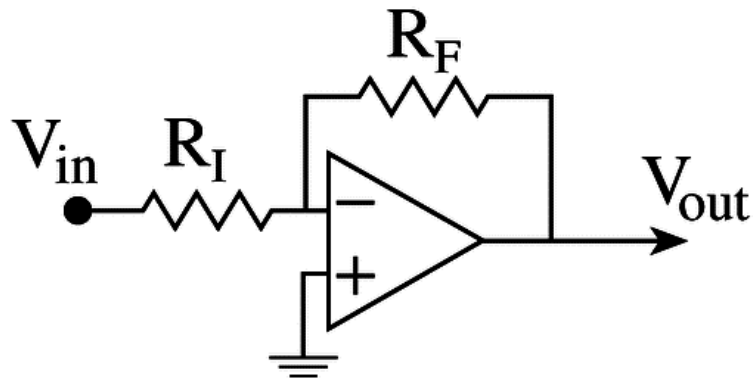
■ Input Impedance

$$R_{in} = R_I$$

■ Output Impedance

$$R_{out} = 0\Omega$$

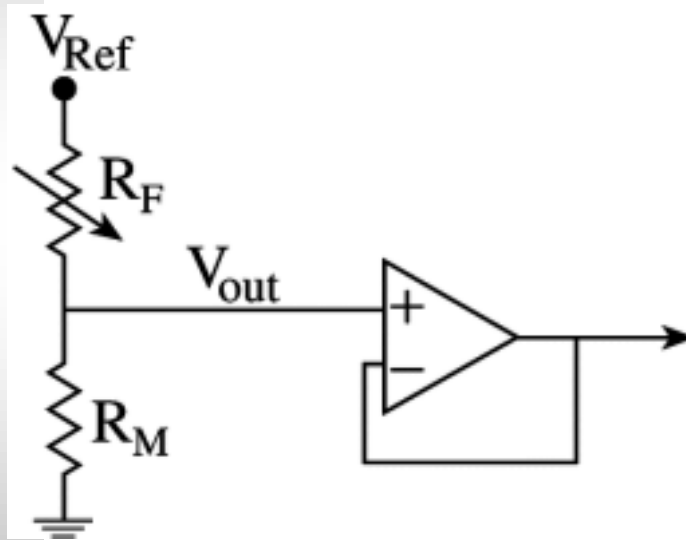
Inverting Amplifier



Resistance to Voltage Conversion

- Voltage divider

Resistance to Voltage: FSRs



- Voltage divider
- V_{out} changes with force
- Buffer amplifier
- Not linear

Bioelectric Sensor