# SNS COLLEGE OF TECHNOLOGY

( An Autonomous Institution)
Coimbatore-35

## DEPARTMENT OF BIOMEDICAL ENGINEERING

## 23BMT203 - BIOMEDICAL TRANSDUCERS AND SENSORS

## UNIT II- Pressure, Displacement and Temperature

## II Year/ IV Sem

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# BIOMEDICAL TRANSDUCERS AND SENSORS

- ✓ Resistive Strain Gauges and Bridge circuit
- ✓ Piezoelectric Transducers
- ✓ Potentiometric Transducers
- ✓ Capacitive, Inductive
- ✓ LVDT Transducers - Principle
- ✓ Equivalent Circuit & Linearity Issues
- ✓ Thermo Resistive - Resistance Temperature Detectors (RTDS)
- ✓ Thermistor Thermo Electric - Thermocouple
- ✓ PN Junction Diode

# Resistive Strain Gauges and Bridge circuit

- ✓ A strain gauge is an example of a passive transducer that converts a mechanical displacement into a change of resistance.
- ✓ It is a thin, wafer-like device that can be attached to a variety of materials by a suitable adhesive to measure the applied strain.
- ✓ As the structure is stressed, the resulting strain deforms the strain gauge attached to the structure.
- ✓ It causes an increase in the resistivity of the gauge which produces an electrical signal proportional to the deformation.
- ✓ The strain gauge displacement sensor consists of a structure attached with the strain gauge that elastically deforms when subjected to a displacement.

# Resistive Strain Gauges and Bridge circuit

**Principle of Operation**

- A resistive strain gauge operates on the fundamental relationship between resistance and the physical dimensions of a conductor:

  $R=\rho L/A$

  where:

  R = Resistance

  ρ= Resistivity of the material

  L= Length of the conductor

  A = Cross-sectional area

# Resistive Strain Gauges and Bridge circuit

## Gauge Factor (GF)

The sensitivity of a strain gauge is measured by the Gauge Factor (GF):

$$GF = \frac{\Delta R/R}{\varepsilon}$$

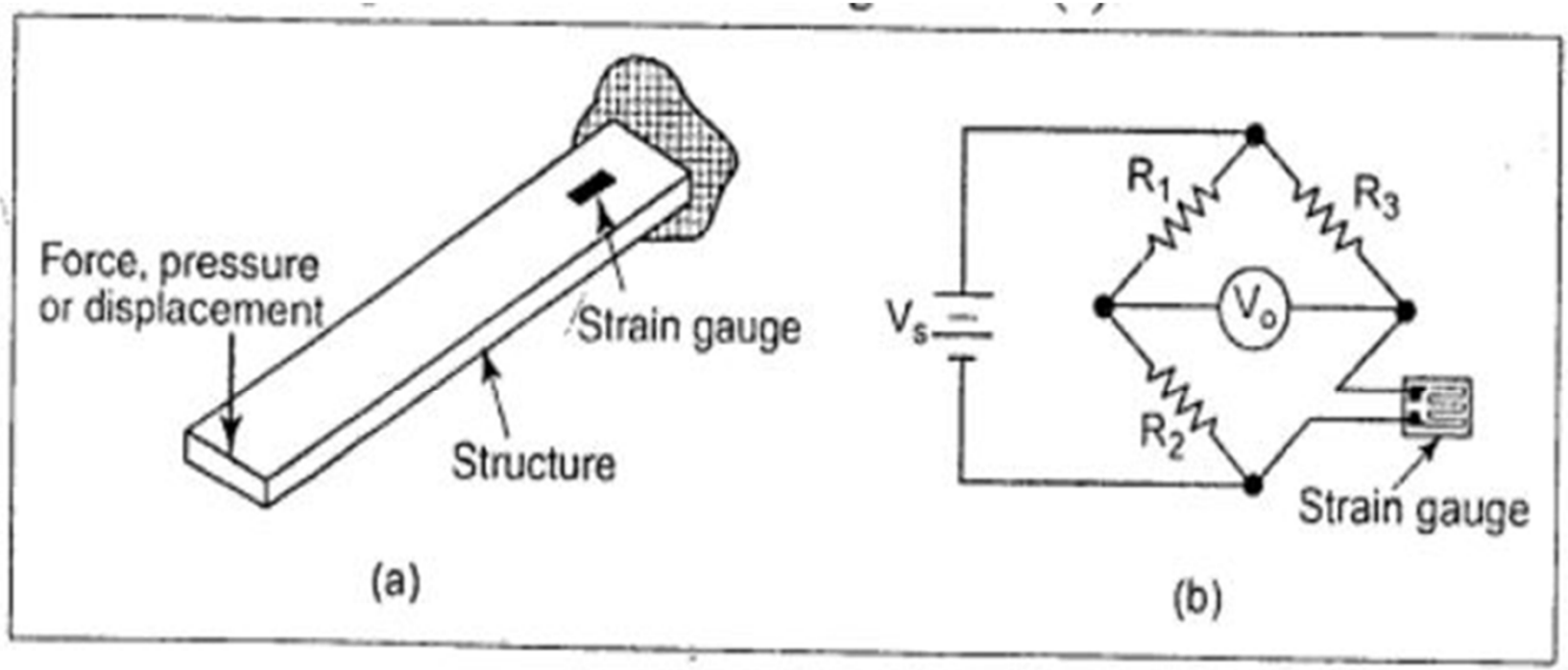
where:

ΔR= Change in resistance

R = Original resistance

ε = Strain

# Resistive Strain Gauges and Bridge circuit




***Strain gauge with Wheatstone bridge circuit***

# Resistive Strain Gauges and Bridge circuit

**Wheatstone Bridge Configuration**

- ✓ A Wheatstone bridge consists of four resistors (R1,R2,R3, R4) arranged in a diamond shape.
- ✓ A voltage source (V) is applied across the bridge, and the output voltage (Vout) is measured across the middle nodes.

$$V_{out} = V_{ex} \times \left( \frac{R_1}{R_1 + R_2} - \frac{R_3}{R_3 + R_4} \right)$$

- ✓ When the bridge is **balanced** (R1/R2=R3/R4), Vout=0V.
- ✓ When strain changes the resistance of the strain gauge, the bridge becomes **unbalanced**, producing a measurable output voltage.

# Resistive Strain Gauges and Bridge circuit

**Bridge Configurations**

There are three main configurations based on the number of active strain gauges:

**(a) Quarter-Bridge Circuit**

One active strain gauge, with three fixed resistors.

Simple but susceptible to temperature variations.

**(b) Half-Bridge Circuit**

Two active strain gauges, placed in opposite arms of the bridge.

Provides temperature compensation and increased sensitivity.

**(c) Full-Bridge Circuit**

Four active strain gauges, with two in tension and two in compression.

Offers maximum sensitivity and best temperature compensation.

# Resistive Strain Gauges and Bridge circuit

**Advantages of Strain Gauge :**

(i) There is no moving part and hence no wear
(ii) Strain gauges are very precise
(iii) It is small and inexpensive
(iv) It has a high-frequency bandwidth.

**Disadvantages of Strain Gauge :**

(i) It is non-linear
(ii) It is very sensitive to temperature.
(iii) It needs to be calibrated regularly
(iv) Strain gauges have to be applied manually. Putting them in their place consuming and costly. It is one of their biggest disadvantages

# Resistive Strain Gauges and Bridge circuit


## Applications

### Engineering and Structural Health Monitoring

- Monitoring strain in bridges, dams, and aircraft components.
- Measuring stress in mechanical components.

### Biomedical Applications

- Monitoring muscle strain in prosthetics.
- Measuring forces in orthopedic research.

### Industrial and Robotics Applications

- Detecting load variations in robotic arms.
- Monitoring machinery vibrations and stress.