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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ASP / BME / SNSCT

BIOMEDICAL TRANSDUCERS AND SENSORS

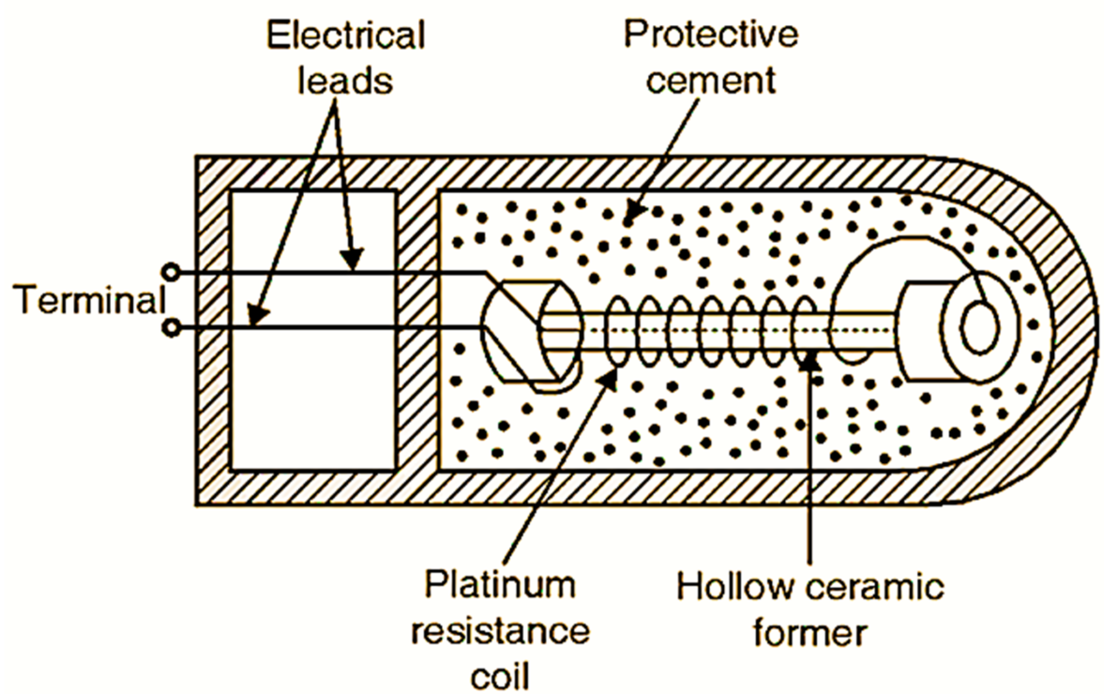
- ✓ Resistive Strain Gauges and Bridge circuit
- ✓ Piezoelectric Transducers
- ✓ Potentiometric Transducers
- ✓ Capacitive, Inductive
- ✓ LVDT Transducers - Principle
- ✓ Equivalent Circuit & Linearity Issues
- ✓ Thermo Resistive - Resistance Temperature Detectors (RTDS)
- ✓ Thermistor Thermo Electric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

Thermo Resistive - Resistance Temperature Detectors (RTDS) & Thermistor

Thermo-resistive sensors operate based on the principle that a material's electrical **resistance changes with temperature**.

The two main types of thermo-resistive sensors are:

1. **Resistance Temperature Detectors (RTDs)**
2. **Thermistors**



Thermo Resistive - Resistance Temperature Detectors (RTDS) & Thermistor

Resistance Temperature Detectors (RTDs)

RTDs are temperature sensors that use a metal resistor whose resistance increases **linearly** with temperature.

1.1. Working Principle

RTDs work based on the formula: $RT=R0(1+\alpha T)$

Where:

- RT = Resistance at temperature TTT
- R0 = Resistance at 0°C
- α = Temperature coefficient of resistance (TCR), a constant for a given metal
- T = Temperature in °C

As temperature increases, the metal's resistance increases proportionally.

Resistance Temperature Detectors (RTDS) & Thermistor

- RTD Materials & Characteristics

Material	Typical Resistance	Temperature Range (°C)	TCR (per °C)
Platinum (Pt100, Pt1000)	100Ω (Pt100), 1000Ω (Pt1000)	-200 to 850°C	0.00385
Copper	10Ω – 100Ω	-200 to 150°C	0.00427
Nickel	100Ω	-60 to 180°C	0.00672

Platinum RTDs (Pt100, Pt1000) are the most common due to **high accuracy and stability**.
Nickel and Copper RTDs are used in lower-precision applications.

Resistance Temperature Detectors (RTDS) & Thermistor

Types of RTDs

1. **Wire-Wound RTD**
    1. A fine metal wire (usually platinum) wound around a ceramic or glass core.
    2. **Highly accurate** but **breakable**.
2. **Thin-Film RTD**
    1. A thin layer of platinum deposited onto a ceramic substrate.
    2. **Compact, durable, and cost-effective**, but slightly less accurate than wire-wound.
3. **Coiled-Element RTD**
    1. A coiled platinum wire is embedded in a ceramic or glass tube.
    2. **Best balance of accuracy and mechanical strength**.

Resistance Temperature Detectors (RTDS) & Thermistor

RTD Wiring Configurations

- RTDs require external circuitry to measure resistance and convert it to temperature. Common wiring types include:

Configuration	Description	Advantage
2-Wire RTD	Simplest, but affected by lead resistance	Least accurate
3-Wire RTD	Compensates for lead resistance	Most common in industry
4-Wire RTD	Eliminates lead resistance effects entirely	Best accuracy

Resistance Temperature Detectors (RTDS) & Thermistor

RTD Advantages & Disadvantages

✓ Advantages

- High accuracy and stability
- Wide operating temperature range
- Excellent repeatability

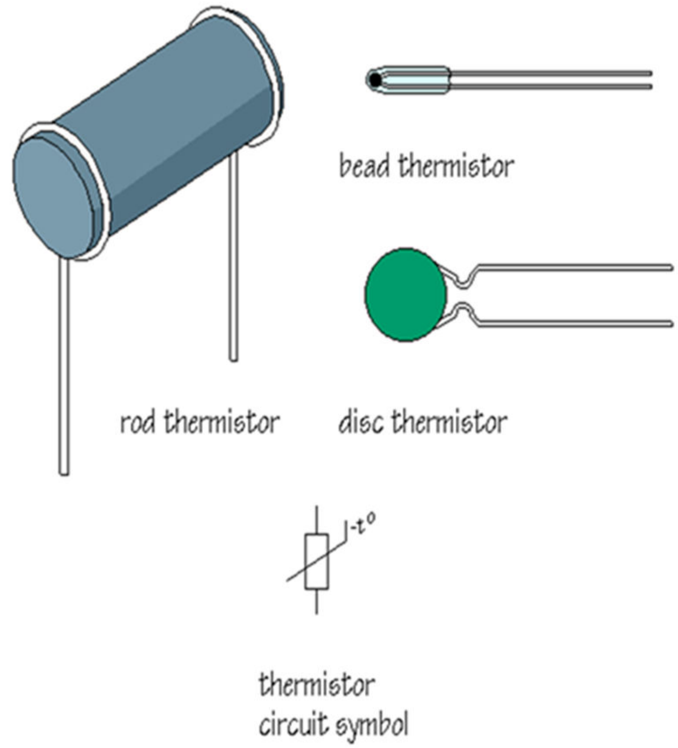
✕ Disadvantages

- More expensive than thermistors
- Requires external excitation current
- Slower response time than thermistors

Resistance Temperature Detectors (RTDS) & Thermistor

Thermistors

Thermistors are temperature-sensitive resistors made from ceramic materials that exhibit a **non-linear** change in resistance with temperature.



Types of Thermistors

1. Negative Temperature Coefficient (NTC) Thermistors

1. Resistance **decreases** as temperature **increases**.
2. Commonly used for **temperature sensing applications** (medical thermometers, HVAC systems).

2. Positive Temperature Coefficient (PTC) Thermistors

1. Resistance **increases** as temperature **increases**.
2. Used in **overcurrent protection circuits** and **self-regulating heating elements**.

Resistance Temperature Detectors (RTDS) & Thermistor

Thermistor Working Principle

- Thermistors follow the **Steinhart-Hart Equation**, which describes resistance as a function of temperature:

$$\frac{1}{T} = A + B\ln(R) + C(\ln(R))^3$$

- Where:
  - T = Temperature in Kelvin
  - R = Resistance of the thermistor
  - A,B,C = Material-specific constants
- Unlike RTDs, thermistors exhibit a **highly nonlinear** resistance change, making them extremely sensitive but requiring complex calibration.

Resistance Temperature Detectors (RTDS) & Thermistor

- Thermistor Characteristics

Parameter	Thermistors (NTC/PTC)	RTDs
Temperature Range	-50 to 150°C (some up to 300°C)	-200 to 850°C
Accuracy	±0.1 to ±1°C	±0.01 to ±0.1°C
Response Time	Fast (milliseconds to seconds)	Slower (seconds to minutes)
Linearity	Non-linear	Linear
Cost	Low	High

Resistance Temperature Detectors (RTDS) & Thermistor

Thermistor Applications

- **Medical devices** (e.g., digital thermometers)
- **HVAC systems** for temperature control
- **Battery temperature monitoring**
- **Automotive coolant temperature sensors**

Thermistor Advantages & Disadvantages

✓ Advantages

- Small and inexpensive
- High sensitivity to temperature changes
- Fast response time

✕ Disadvantages

- Non-linear response
- Limited temperature range
- Requires calibration

Comparison: RTDs vs. Thermistors

Feature	RTD (Platinum)	Thermistor
Material	Platinum, Nickel, Copper	Ceramic, Metal Oxides
Temperature Range	-200°C to 850°C	-50°C to 150°C (some up to 300°C)
Linearity	Linear	Non-linear
Accuracy	High (±0.01 to ±0.1°C)	Moderate (±0.1 to ±1°C)
Response Time	Slower	Faster
Cost	Expensive	Cheaper
Best for	Industrial & scientific use	Consumer electronics, medical devices