



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



Differential Pressure Measurements using capacitive, inductive Sensor



- ✓ Two independent pressure sensors can be used to measure a pressure difference.
- ✓ If the pressure difference is small compared to the variations in each sensor, slight changes in sensitivity and zero level may lead to significant measurement errors.
- ✓ In such cases, direct measurement of differential pressure is preferred to ensure accuracy.



Differential Pressure Measurements using capacitive, inductive Sensor



Definition:

Differential pressure (ΔP) is the difference between two pressures applied to a sensor

$$\Delta P = P_1 - P_2$$

Used for **flow measurement, level sensing, and filter monitoring**. Requires **high accuracy, stability, and reliability**, especially in industrial and medical applications.



Differential Pressure Measurements using capacitive, inductive Sensor



Working Principle

A **capacitive pressure sensor** consists of a **flexible diaphragm** placed between two fixed capacitor plates.

The diaphragm deflects in response to the applied differential pressure (P1 and P2), altering the capacitance.

Capacitance is given by: $C = \epsilon A d$

where:

- ϵ = dielectric permittivity,
- A = area of the capacitor plates,
- d = distance between plates.
- A **change in d** due to diaphragm movement modifies capacitance, which is then converted into a proportional voltage or current.



Differential Pressure Measurements using capacitive, inductive Sensor



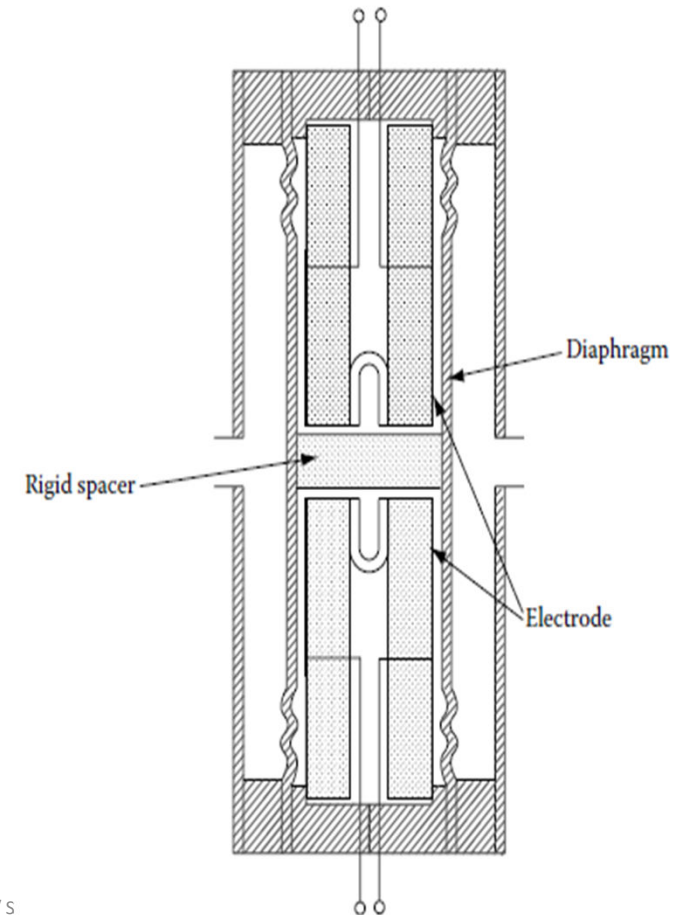
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Differential Pressure Measurements using capacitive, inductive Sensor



Construction of Capacitive Differential Pressure Sensor

Diaphragm: A flexible membrane (typically made of silicon or metal).

Electrode Plates: Placed on either side of the diaphragm to form a capacitor.

Sealed Chamber: Ensures pressure is applied to the diaphragm without external interference.

Signal Processing Circuit: Converts capacitance variations into readable electrical signals.



Differential Pressure Measurements using capacitive, inductive Sensor



Advantages of Capacitive Sensors

High sensitivity to small pressure changes.

Low power consumption, making them suitable for battery-powered applications.

Fast response time for real-time pressure monitoring.

Excellent long-term stability with minimal drift.

Disadvantages of Capacitive Sensors

Affected by **temperature and humidity variations**.

Requires **precise calibration** to maintain accuracy.

Not ideal for **high-pressure environments** due to diaphragm limitations.

Applications of Capacitive Differential Pressure Sensors

- ◆ **Flow measurement** in pipelines using Venturi tubes and orifice plates.
- ◆ **HVAC systems** for air filter monitoring.
- ◆ **Medical devices** (respiratory and blood pressure monitoring).
- ◆ **Level sensing** in closed tanks and reservoirs.



Differential Pressure Measurements using capacitive, inductive Sensor



Differential Pressure Measurement Using Inductive Sensors

Working Principle

- **Inductive differential pressure sensors** work on the principle of **mutual inductance**.
- A **diaphragm** moves in response to pressure differences, shifting the position of a ferromagnetic core inside an inductive coil system.
- This movement **alters the inductance**, producing a differential output signal proportional to pressure variation.



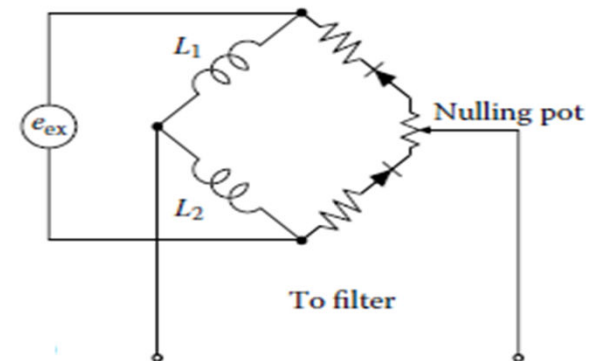
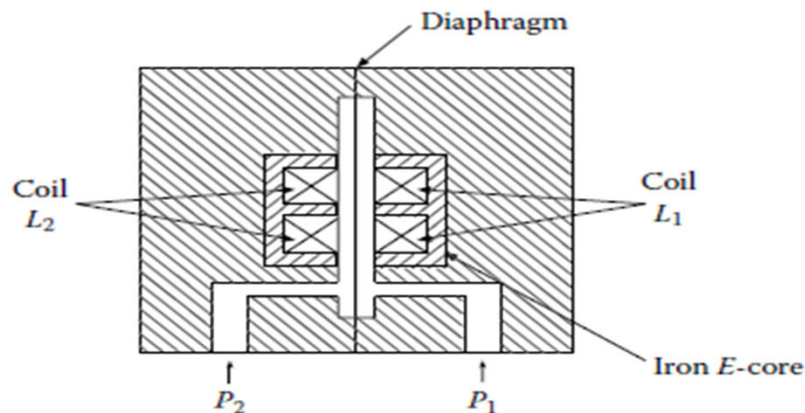
Differential Pressure Measurements using capacitive, inductive Sensor



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Differential Pressure Measurements using capacitive, inductive Sensor



Types of Inductive Differential Pressure Sensors

LVDT-Based Sensors (Linear Variable Differential Transformer)

1. Uses a **primary coil** and two **secondary coils** wound around a cylindrical core.
2. When the diaphragm moves, it displaces the core, causing an imbalance in mutual inductance.
3. The differential voltage output is proportional to the pressure difference.

Eddy Current Sensors

1. Uses a conductive diaphragm and a coil.
2. Pressure changes **alter the distance between the diaphragm and coil**, modifying eddy current losses.
3. The sensor converts this into a measurable electrical signal.

Construction of Inductive Differential Pressure Sensor

- **Flexible Diaphragm:** Moves under pressure difference.
- **Magnetic Core:** Attached to the diaphragm, moves inside the coil assembly.
- **Primary and Secondary Coils:** Detect changes in mutual inductance.
- **Signal Conditioning Circuit:** Converts inductance changes into voltage or current output.



Differential Pressure Measurements using capacitive, inductive Sensor



Advantages of Inductive Sensors

Highly accurate and reliable for dynamic pressure variations.

Resistant to harsh environments (high temperature, vibration, and EMI).

Suitable for **high-pressure and industrial applications**.

Long lifespan with minimal wear and tear.

Disadvantages of Inductive Sensors

Requires **complex signal processing** to convert inductance changes into readable data.

More **expensive** than capacitive sensors.

Slightly **slower response time** compared to capacitive sensors.

Applications of Inductive Differential Pressure Sensors

Aerospace and automotive pressure control systems.

Hydraulic and pneumatic pressure monitoring.

Industrial process control (oil and gas, power plants).

Scientific research instrumentation for high-precision measurements.



Differential Pressure Measurements using capacitive, inductive Sensor



Feature	Capacitive Sensor	Inductive Sensor
Working Principle	Change in capacitance due to diaphragm movement	Change in inductance due to core displacement
Sensitivity	High	Moderate to High
Accuracy	Very High	High
Temperature Stability	Affected by temperature and humidity	More stable with proper shielding
Durability	Moderate	High (rugged applications)
Response Time	Fast	Moderate
Power Consumption	Low	Moderate
Cost	Lower	Higher
Applications	HVAC, medical, industrial automation	Aerospace, automotive, heavy industries