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AUTONOMOUS INSTITUTION
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VI Semester

CBM 370 - Wearable Devices

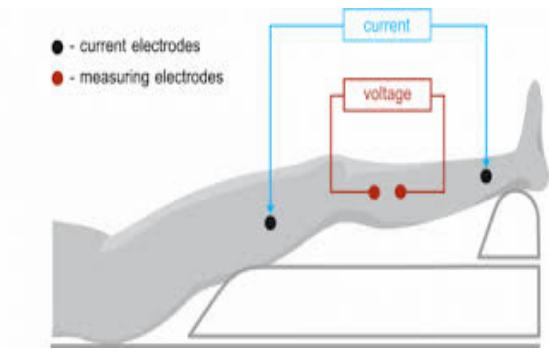
Unit- 1 INTRODUCTION TO WEARABLE SYSTEMS AND SENSORS

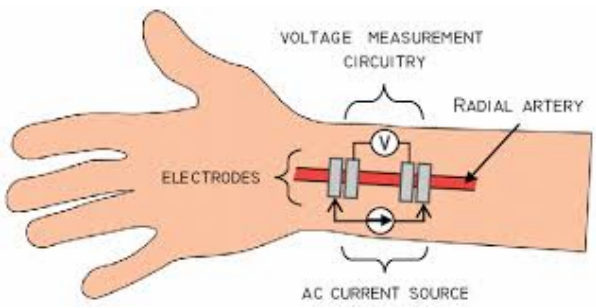
1.7 Impedance Plethysmography

- Impedance Plethysmography (IPG) is a **non-invasive technique** used to measure **blood flow, volume changes, and body composition** by analyzing electrical impedance variations in biological tissues.
- It is widely used in **vascular studies, cardiopulmonary monitoring, and body composition analysis**.

Principle:

- **Low-Frequency Current** (~1-5 mA, 50-100 kHz) is passed through the body using **current electrodes**.
- **Voltage Changes** are recorded by separate **measuring electrodes** placed on the skin.
- As **blood volume changes**, the **electrical impedance varies**, allowing the detection of pulsatile blood flow and other physiological parameters.





Components of IPG System

1. **Electrodes Placement**
   - ✓ **Current Electrodes (Black dots in the image)** – Apply AC current through the tissue.
   - ✓ **Voltage Electrodes (Red dots in the image)** – Measure the voltage drop caused by impedance variations.
2. **Signal Processing Unit**
   - ✓ Converts impedance changes into measurable electrical signals.
   - ✓ Filters noise and artifacts.
3. **Computer/Data Display Unit**
   - ✓ Analyzes and visualizes blood flow, body composition, or respiratory patterns.

Working of IPG:

1. **Current Injection:** A small alternating current is passed through the body using a pair of electrodes (shown in black).
2. **Voltage Measurement:** A second pair of electrodes (shown in red) measures the voltage drop across a specific segment of the body (in this case, the leg).
3. **Impedance Calculation:** The impedance (opposition to the flow of current) is calculated using Ohm's Law (Impedance = Voltage / Current).
4. **Volume Changes:** Changes in the volume of blood or other fluids within the measured segment affect the impedance. For instance, an increase in blood volume will decrease the impedance.

Applications of Impedance Plethysmography

1. Cardiovascular & Vascular Studies

- ❒ Deep Vein Thrombosis (DVT) Detection – Monitors venous blood flow changes in the legs.
- ❒ Peripheral Arterial Disease (PAD) Diagnosis – Evaluates blood circulation in limbs.
- ❒ Cardiac Output Measurement – Estimates heart function based on thoracic impedance.

2. Respiratory Monitoring:

- ❒ Thoracic Impedance Plethysmography – Assesses lung function and breathing patterns.
- ❒ Sleep Apnea Detection – Identifies breathing disturbances during sleep.

3. Body Composition Analysis:

- ❒ Fat vs. Lean Mass Estimation – Used in Bioelectrical Impedance Analysis (BIA) for fitness and medical assessments.
- ❒ Hydration Status Monitoring – Determines extracellular vs. intracellular water levels.

Advantages of IPG

- ✓ **Non-invasive & Safe** – No needles or radiation.
- ✓ **Continuous Monitoring** – Real-time data collection.
- ✓ **Portable & Easy to Use** – Often used in bedside and home monitoring systems

Limitations of IPG

- ✓ **Sensitive to Motion Artifacts** – Body movement can affect accuracy.
- ✓ **Skin Contact Issues** – Poor electrode placement can lead to incorrect readings.
- ✓ **Limited in Severe Conditions** – May be less effective in patients with extreme fluid retention or severe cardiovascular issues

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