

OMD551- BASICS OF BIOMEDICAL INSTRUMENTATION

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Lecture 1

BMI

UNIT I - BIO POTENTIAL GENERATION AND ELECTRODES TYPES

Origin of bio potential and its propagation. Types of electrodes - surface, needle and micro electrodes and their equivalent circuits.

Recording problems - measurement with two electrodes.

UNIT II - BIOSIGNAL CHARACTERISTICS AND ELECTRODE CONFIGURATIONS

Biosignals characteristics – frequency and amplitude ranges. ECG – Einthoven's triangle, standard 12 lead system. EEG – 10-20 electrode system, unipolar, bipolar and average mode. EMG – unipolar and bipolar mode.

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UNIT III SIGNAL CONDITIONING CIRCUITS

Need for bio-amplifier - differential bio-amplifier, Impedance matching circuit, isolation amplifiers, Power line interference, Right leg driven ECG amplifier, Band pass filtering

UNIT IV MEASUREMENT OF NON-ELECTRICALPARAMETERS

Temperature, respiration rate and pulse rate measurements. Blood Pressure: indirect methods - Auscultatory method, direct methods: electronic manometer, Systolic, diastolic pressure, Blood flow and cardiac output measurement: Indicator dilution, and dye dilution method, ultrasound blood flow measurement.

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UNIT V- BIO-CHEMICAL MEASUREMENT

Blood gas analyzers and Non-Invasive monitoring, colorimeter, Sodium Potassium Analyser, spectrophotometer, blood cell counter, auto analyzer (simplified schematic description).

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BIO MEDICAL INSTRUMENTATION

BASICS OF BMI

APPLICATION

Origin of bio potential and its propagation

- The **origins** of these **biopotentials** can be traced to the electric activity at the cellular level. The electric potential across a cell membrane is the result of different ionic concentrations that exist inside and outside the cell. ... Each cell in the heart produces a characteristic action potential.

Origin of bio potential and its propagation

Bioelectric Potential

Biopotentials

Electrocardiogram (ECG)

Electroencephalogram (EEG)

Electroneurogram (ENG)

Electromyogram (EMG)

Electroretinogram (ERG)

Ion Distribution

- Particles / molecules – electrically charged
- Anions – negatively charged
- Cations – positively charged ~

Ion Distribution

- Anions (-)

Large intracellular proteins

Chloride ions Cl^-

- Cations (+)

Sodium Na^+

Potassium K^+

Resting Membrane Potential

Resting potential: The diffusion and drift processes rise to a balance of ions between inside and outside of the cell

OUTSIDE - + ion

Cell Membrane

INSIDE - - ions

Membrane is polarized

- more negative particles in than out
- Bioelectric Potential – like a battery
- Potential for ion movement – current

Resting Membrane Potential

OUT SIDE – POSITIVE

Membrane

INSIDE SIDE – NEGATIVE

Membrane Potential

- Net bioelectric potential for all ions
- Balance of both gradients concentration & electrostatic
- Units = millivolts (mV)
- $V_m = -65 \text{ mV}$ – given by Goldman equation

Resting potential

- $V_m = \frac{RT}{ZF} \ln \frac{P_K [K^+]_o + P_{Na} [Na^+]_o + P_{Cl} [Cl^-]_o}{P_K [K^+]_i + P_{Na} [Na^+]_i + P_{Cl} [Cl^-]_i}$

$$ZF \quad P_K [K^+]_i + P_{Na} [Na^+]_i + P_{Cl} [Cl^-]_i$$

- P = permeability
- Net potential movement for all ions
- known V_m : Can predict direction of movement of any ion

SODIUM-POT PUMP

- The **sodium–potassium pump** is found in many cell (plasma) membranes. Powered by ATP, the **pump** moves **sodium** and **potassium** ions in opposite directions, each against its concentration gradient. In a single cycle of the **pump**, three **sodium** ions are extruded from and two **potassium** ions are imported into the cell.

sodium potassium pump work

- The **sodium-potassium pump** moves **sodium** ions out of and **potassium** ions into the cell. This **pump** is powered by ATP. For each ATP that is broken down, 3 **sodium** ions move out and 2 **potassium** ions move in. ... **Sodium** ions bind to the **pump** and a phosphate group from ATP attaches to the **pump**, causing it to change its shape

sodium potassium pump work

What would **happen** if it stopped **working**?

It maintains the concentration gradients of Na^+ and K^+ , helping to stabilize resting membrane potential. **If** stopped **working**, electrochemical gradient would equalize/disappear and actions potentials could not be generated, so the cell would **stop working**.

IMPORTANT OF NA-K PUMP

- The **sodium-potassium pump** is integral in maintaining the acid-base balance as well as in healthy kidney function. Energy is derived from **pumping sodium** outside the cell, where it becomes concentrated, wanting to push its way back in. This energy is used to remove acid from the **body**.

USES

- In the **kidneys** the Na-K pump helps to maintain sodium and potassium balance in our body. It also plays a key role in maintaining **blood** pressure and controls cardiac contractions. Failure of the Na-K pump can result in the swelling of the **cell**

Lecture 2

Characteristics of RP

- Depends upon the temp
- The permeability of the various cell varied
- Range of restion potentials: -60 to -100mv

Action potential

- The positive potential of the cell membrane during the excitation is called as the action potential.

OUT SIDE - - ion

Cell Membrane

INSIDE- + ions

Conduction velocity

- The rate at which an action potential moves down a fiber or propagated from the cell to cell

All or nothing law

- It states that regardless of the method of excitation of cells or the intensity of the stimulus, the action potential always same for any given cell

Types of electrodes

- Pick Up The Electrical Signal From The Human Body
- Electrode Paste
- A bioelectrode is a conductor that is designed to serve as an interface between biological structures and electronic systems. Its function is to either sense and measure (passive) the electrical activity within the biological structure or stimulate (active) it by inducing external electrical potential.

Half-Cell Potential

Half-Cell Potential

- **Half-Cell potential is determined by**
- Metal involved
 - Concentration of its ion in solution
- -Temperature
- -And other second order factor

Half Cell Potential and Nernst Equation

- When two ionic solutions of different concentration are separated by semipermeable membrane, an electric potential exists across the membrane.
- $E = - \frac{RT}{nF} \ln a_1/a_2$
- a_1 and a_2 are the activity of the ions on each side of the membrane. **Ionic activity** is the availability of an ionic species in solution to enter into a reaction

Surface electrodes:

- Surface electrodes:
 - Larger area electrodes : ECG potentials
 - Smaller area electrodes: EEG & EMG potentials
 - Types:
 - Metal plate electrodes
 - Suction cup electrode
 - Adhesive tape electrode
 - Multipoint electrode
 - Floating electrode

Metal plate electrodes:

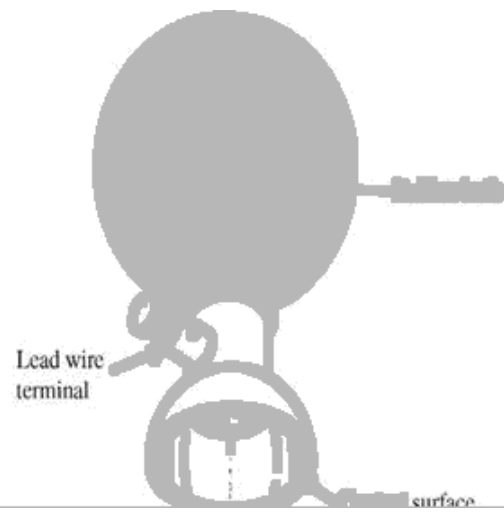


Metal plate electrodes

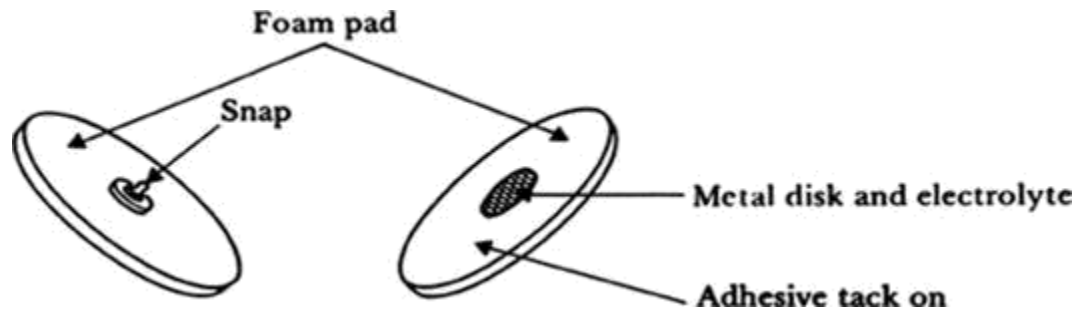
- Rectangular(cm x 5 cm)circular(4.75diameter) in shape
- German silver, nickel silver, nickel plated steel ECG measurements

Suction Cup electrode

- Flat surfaces of the body and to regions where the underlying tissue is soft
- Physically large but only rim (smaller area) is in contact to the skin



Adhesive tape electrode



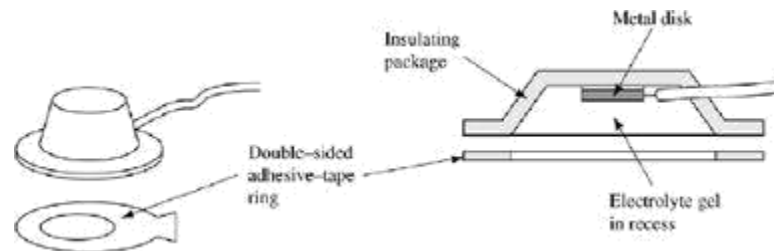
Adhesive tape electrode

- The pressure of surface electrode against the skin may squeeze the electrode paste out
- So, this type of electrodes are used
- Light metallic screen backed by a pad for electrode paste

Disposable Foam-Pad Electrodes

- Disposable foam-pad electrodes, often used with electrocardiograph monitoring apparatus

Floating electrode



NEEDLE ELECTRODES

- *Needle electrodes are generally used in clinical electro myography, neuro graphy and other electrophysiological investigations under the skin and in the deeper tissues.*
- Material used: Stainless steel which is preferred due to its mechanical solidity and low price.

Depth & needle electrode

- Depth electrode:
- Used to study the electrical activity of the neurons in superficial layers of the brain & also the oxygen tension
 - Bundle of Teflon insulated platinum
- (90%) & Iridium (10%) alloy wires
 - End of supporting wire is rounded
 - Active area : 0.5 mm²

Monopolar Needle

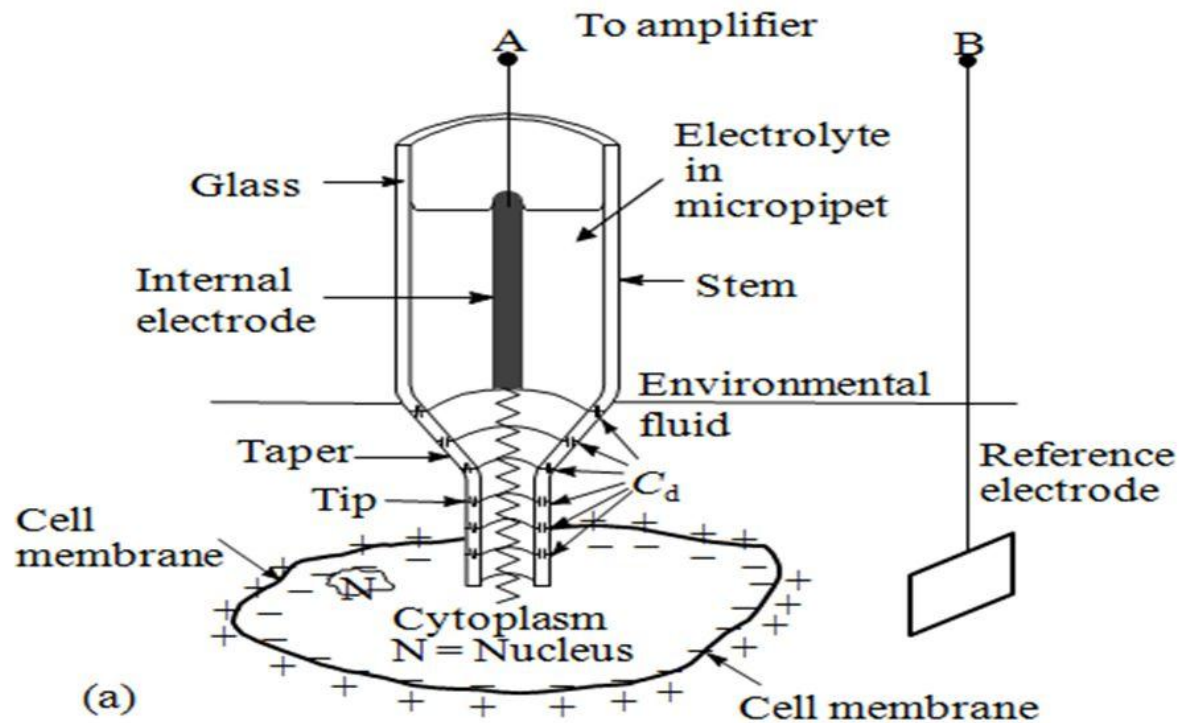
- Made of stainless steel, the monopolar needle electrode has a very finely sharpened point and is covered with Teflon or other insulating material over its entire length, except for a 0.5 mm exposure at the tip. The needle serves as the active electrode, and a surface electrode placed on the skin close to it serves as a reference.

Micro electrodes

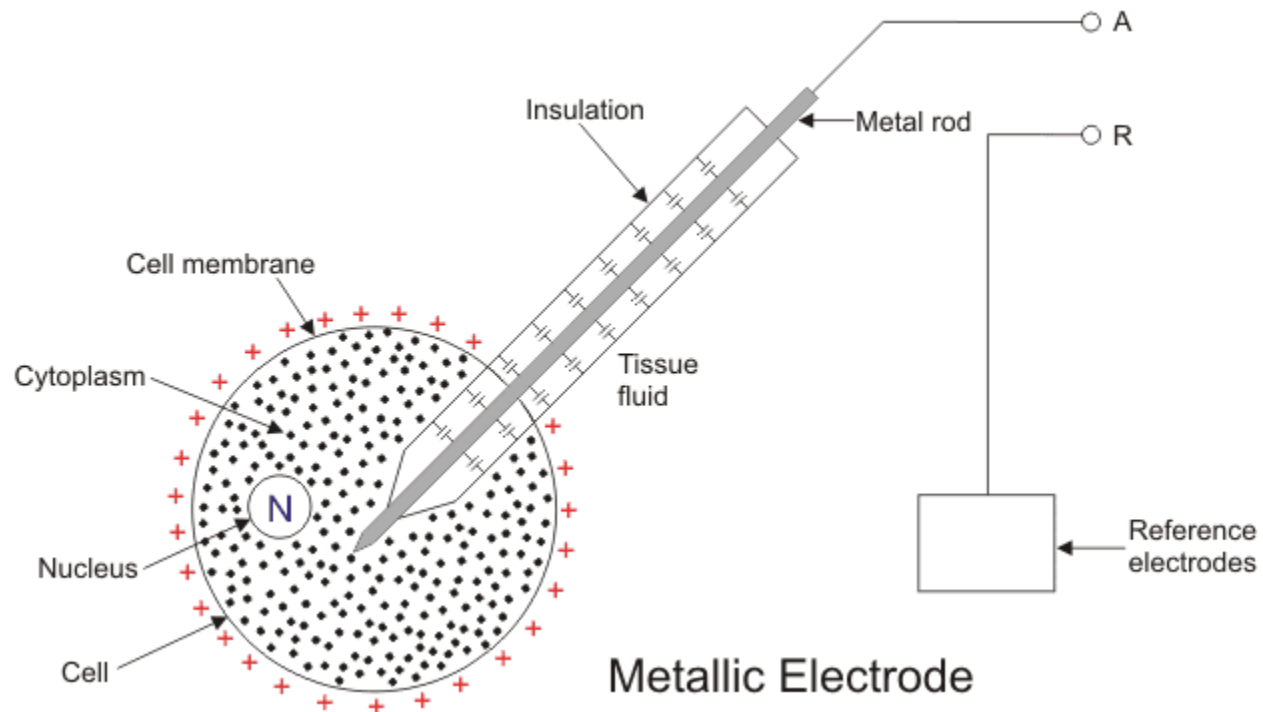
- **Microelectrodes** are biopotential electrodes with an ultrafine tapered tip that can be inserted into individual biological cells. These electrodes serve an important role in recording action potentials from single cells and are commonly used in neurophysiological studies

Micropipettes

MICROPIPET

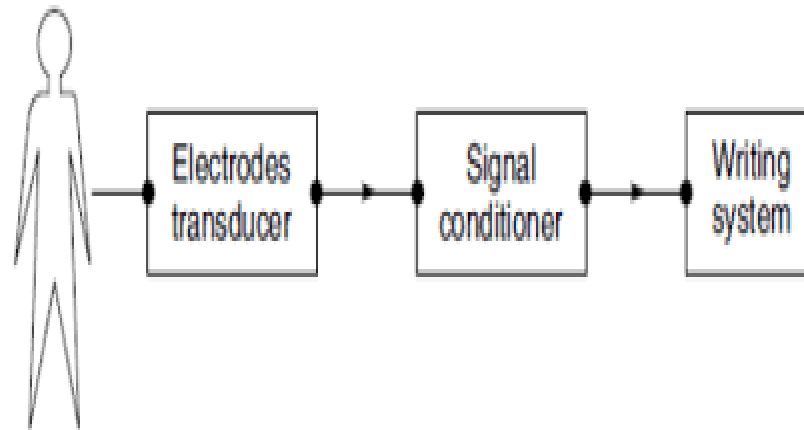


Metallic electrodes



- BASICS COMPONENTS OF BIO MEDICAL SYSTEM
- Electrode
- Transducer
- Signal processing

RECORDING PROBLEMS



recorders

- The **recorder** is required in any **instrumentation** system to record data which has been acquired. Data can be in analog or digital form hence the 2 **types of recorders** namely: Analog **recorder**.
Digital **recorder**

types

- Potentiometric recorder
- Direct writing recorder
- Inkject recorder
- Electrostatic recorder
- Thermal array recorder

Problems encountered in measuring a living system

- 1. Inaccessibility of variable to measurement: it is greatest difficulty in attempting from a living system is the problem in gaining to the variable being measured. For example neuro chemical activity of brain ,it is impossible to place transducer so we need to do the indirect measurement.in using indirect measurement, however one must be aware of the limitations.

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Problems encountered in measuring a living system:

- 2. Variability of data: majority of physiological variables are nondeterministic, means varies with respect to time. so these must be represented by some statistical or probability distribution.

Problems encountered in measuring a living system:

- 3. Lack of knowledge of interrelationship: physiological measurements with large tolerance are often accepted by the physician because of lack of this knowledge and the resultant inability to control variations. Better understanding of physiological relationship would also permit more effective use of indirect measurements as substitutes for inaccessible measure.

Problems encountered in measuring a living system:

- 4. Interaction among physiological systems: large number of feedback loops involved in the major physiological systems, a severe degree of interaction exists both within a given system and among the major systems. The result is that stimulation of one part of a given system generally affects all other parts of the system in some way and often affects other systems as well.

- 5. Effect of transducer: Transducer can be considered as a device converting one form of energy to another form. Electrical transducers can be considered as a device meant to convert a form of energy to equivalent electrical signals. The physical quantity to be measured can be position, displacement, flow, temperature, strain, velocity etc. and the output is in the form of electrical parameters like current, capacitance, voltage, inductance, change in resistance etc

Problems encountered in measuring a living system:

6. Artifacts: it is component or variable is observed while doing experiment, which is not naturally present. Thus random noise generated within the measuring instrument, electrical interference (50

Problems encountered in measuring a living system:

- 7. Energy limitations: many physiological measurement techniques that a certain amount of energy be applied to the living system in order to obtain a measurement. For example, resistance measurements require the flow of electric current through the tissue or blood being measured. Some transducers generate small amount of heat due to the current flow.

Problems encountered in measuring a living system:

- 8. Safety considerations: methods employed in measuring variables in a living human subject must in no way endanger the life or normal functioning of the subject. Recent emphasis on hospital safety requires that extra caution must be taken in the design of any measurement system to protect the patient.

Measurement with two electrodes

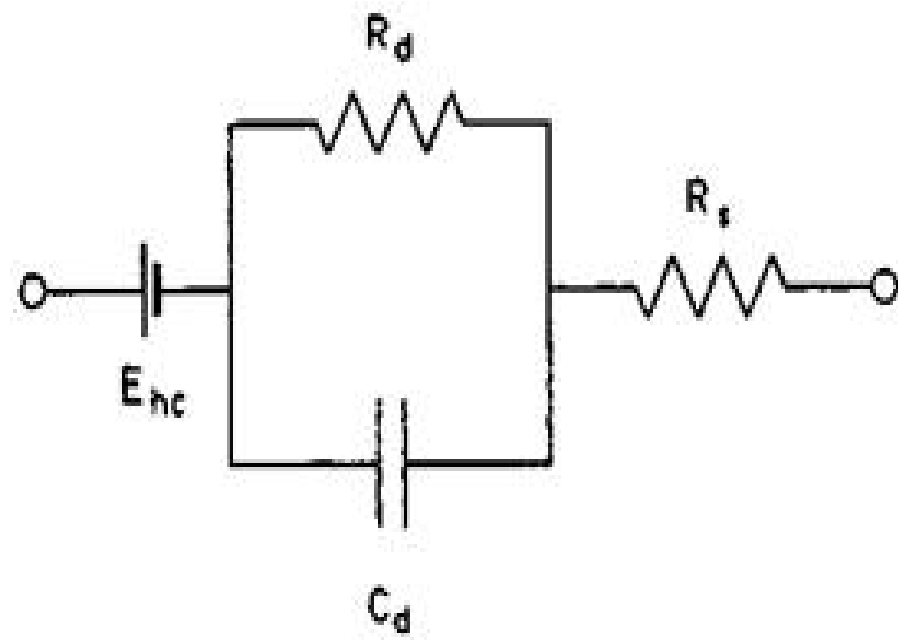
- **Measurement** of bioelectric potentials requires **two electrodes**. The resulting voltage potential is the difference between the potential of microelectrode and reference **electrode**. ... E_A – metal **electrode**-electrolyte potential at microelectrode tip. E_B – Reference **electrode**-electrolyte potential.

Electrode used

- Micro electrode
- Skin electrode
- needle electrode

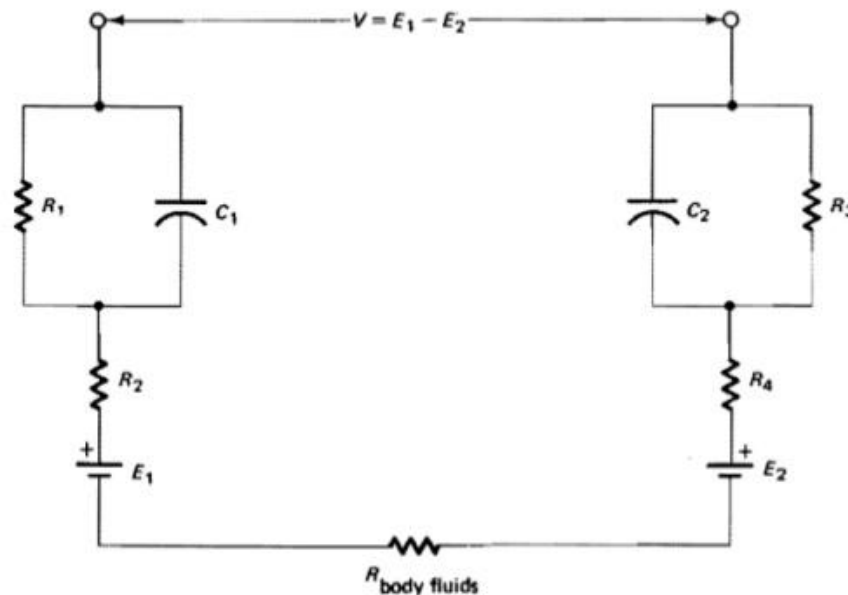
Equivalent circuit for a **biopotential electrode**

- **Equivalent circuit for a biopotential electrode** in contact with an electrolyte. ... R_d and C_d make up the impedance associated with the **electrode-electrolyte interface** and polarization effects, and R_s is the series resistance associated with **interface** effects and due to resistance in the electrolyte.



Measurement of biopotential with two electrode

EQUIVALENT CIRCUIT OF BIOPOTENTIAL ELECTRODE INTERFACE



Measurement of biopotentials with two electrodes—equivalent