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# Rajshahi University of Engineering & Technology

## Department of Electrical & Electronic Engineering

## LAB REPORT

**Course No** : EEE 4262

**Course Title** : Biomedical Engineering Sessional

**Experiment no** : 01

**Name of the Experiment:** Study of physical fitness by using impedance measurementtechnique and analyzing body composition

| **Submitted By** | **Submitted To** |
| --- | --- |
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| Department : EEE | Assistant Professor, |
| Roll : 1801105 | Department of EEE, |
| Section : B | RUET |

## Experiment No: 01

**1.1: Name of the experiment:** Study of physical fitness by using impedance measurement technique and analyzing body composition.

**1.2. Objectives:**

- To know about various physical and biological parameters of human body.
- Top observe how physical fitness can be measured using these various parameters of a human body.
- To know how impedance measurement can be performed in a human body using electrodes.
- To compare the obtained result with BMI and make a proper conclusion about the method.

**1.3. Theory:**

**Bioelectrical impedance analysis** (**BIA**) is a method for estimating body composition, in particular body fat and muscle mass, where a weak electric current flows through the body and the voltage is measured in order to calculate impedance (resistance and reactance) of the body. Most body water is stored in muscle. Therefore, if a person is more muscular there is a high chance that the person will also have more body water, which leads to lower impedance.

Here the various important body parameters and their corresponding reference value is given:

- **Total body water**: It is one of the most important parameters for a human body fitness. It is divided into two categories. Extracellular water(ECW) and Intracellular(ICW) water.

| Gender | ECW(%) | ICW(%) | TBW(%) |
|---|---|---|---|
| Male | 26 | 34 | 55-65 |
| Female | 20 | 30 | 50-60 |

- **Fat**: The ratings of fat for a healthy man are:

| Gender | Low(%) | High(%) |
|---|---|---|
| Male | 12 | 18 |
| Female | 20 | 26 |

- **BMI:** It means Body Mass Index.

$$\text{BMI}=\frac{weight\ in\ kg}{(Height\ in\ meter)^2}$$

| ***Body Mass Index*** | ***Classification*** |
|---|---|
| < 18.5 | Under Weight |
| 18.5 - 24.9 | Normal Weight |
| 25 - 29.9 | Over Weight |
| 30.0 - 34.9 | Obesity Class 1 |
| 35.0 - 39.9 | Obesity Class 2 |
| 40 or above | Obesity Class 3 |

- **Prediction Marker:** It is the main parameter of human body physical fitness measured by impedance measurement method. It denotes the proper fluids distribution and activity in body.

$$\text{Prediction marker}=\frac{impedance\ at\ 200\ Hz}{Impedance\ at\ 5\ KHZ}$$

| **Prediction Marker** | **Condition** |
|---|---|
| 0.701-0.82 | Normal |
| 0.82-0.89 | Caution |
| 0.891-0.999 | Illness |

- **Phase angle:** In bioelectrical impedance analysis in humans, an estimate of the phase angle can be obtained and is based on changes in resistance and reactance as alternating current passes through tissues, which causes a phase shift. A phase angle therefore exists for all frequencies of measurement.

| Phase Angle (degree) | Condition |
|---|---|
| 3.5-5.4 | Poor |
| 5.4-6.4 | Satisfactory |
| 6.4-7.9 | Good |

## 1.4. Measurement Method:

To measure the impedance of a human body, two electrodes are placed at the left arm and two electrodes are placed at left foot. Then using the measurement device, the impedance and other corresponding parameters are measured.

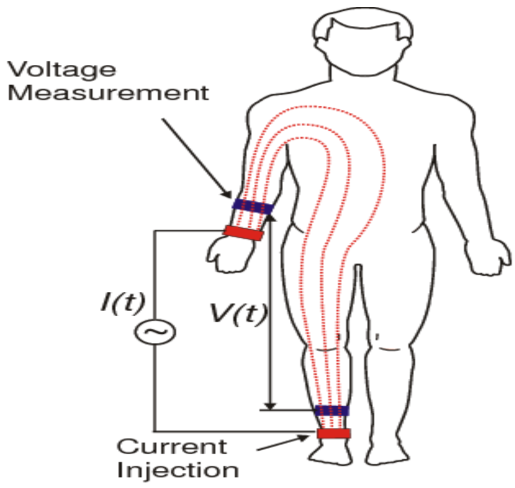


**Fig.1.1**. Impedance measurement in human body

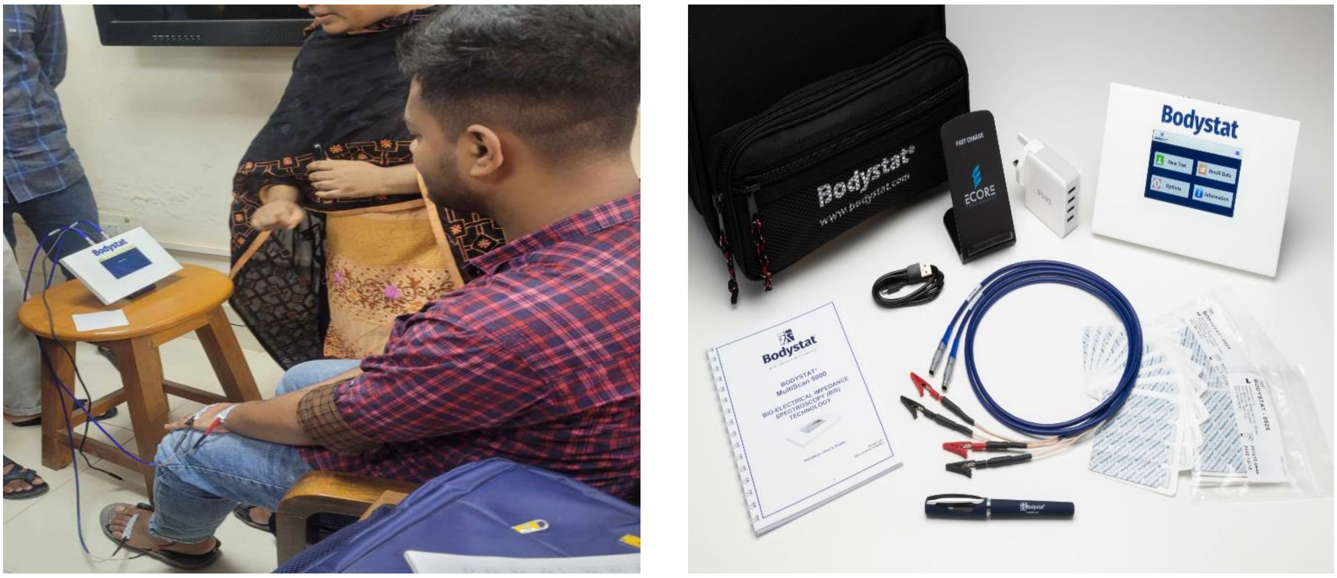


**Fig.1.2**. Impedance measurement in Laboratory

## 1.5. Obtained Data:

| Subject Ref. | Name | Gender | Activity | Height | Weight | Fat (%) | Water (%) | ECW (%) | ICW | BMI | PHASE ANGLE (°) | Prediction Marker |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 105 | Shanto | Male | Medium | 1.68 | 85 | 17.3 | 85.2 | 23.2 | 52.7 | 30.2 | 8.72 | 0.731 |
| 106 | Shuvo | Male | Medium | 1.78 | 58 | 11.8 | 79.1 | 24.9 | 31.4 | 18.3 | 7.11 | 0.772 |
| 107 | Noha | Female | Medium | 1.6 | 42 | 21.1 | 119.4 | 24.2 | 40 | 16.4 | 5.5 | 0.831 |
| 108 | Forid | Male | Medium | 1.7 | 65 | 9.5 | 81.4 | 24.7 | 36.9 | 22.4 | 8.93 | 0.718 |

## 1.6. Result & Discussion:

In this experiment, we performed the measurement of physical fitness of human body using the impedance measuring method. All the measurement was performed satisfactorily by placing just two electrodes in arm and foot. From the observed data, we see that for all the person, the prediction marker was accurate in the correct range. As they were all young according to the age, their all ratings including TBW, FAT, Prediction Marker all were in the perfect range. For some person, their phase angle was above 7.9 which denotes the very good result. Higher phase angle means higher reactance and high body water. Which further denotes a healthy body.

If we compare the Prediction Marker with BMI, The normal or Obesity BMI has the perfect Prediction Marker but the underweight BMI person also the Prediction marker in perfect range.

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# Rajshahi University of Engineering & Technology

## Department of Electrical & Electronic Engineering

## LAB REPORT

**Course No** : EEE 4262

**Course Title** : Biomedical Engineering Sessional

**Experiment no** : 02

**Name of the Experiment:** Observation of cardiac state of different situations (Relax and after walking)


**Submitted By**

Md Maruf Hassan

Department : EEE

Roll : 1801105

Section : B

**Submitted To**

Kusum Tara

Assistant Professor,

Department of EEE,

RUET

**Experiment No: 02**

**2.1. Name of the experiment:** Observation of cardiac state of different situations (Relax and after walking)

**2.2. Objectives:**

- To know about the cardiac cycle in human body
- To know how the cardiac cycle is generated and observe the cardiac cycle
- To observe the ECG signal and observe how heart rate is calculated from it
- To compare the heart rate at relax state and the state after walking

**2.3. Theory:**

Electrocardiography is the process of producing an electrocardiogram (ECG or EKG), a recording of the heart's electrical activity through repeated cardiac cycles. It is an electrogram of the heart which is a graph of voltage versus time of the electrical activity of the heart using electrodes placed on the skin. These electrodes detect the small electrical changes that are a consequence of cardiac muscle depolarization followed by repolarization during each cardiac cycle (heartbeat).

Traditionally, "ECG" usually means a 12-lead ECG. In a 12-lead ECG, 4 electrodes are connected with the 2 arms and 2 foots. The other 6 electrodes are connected with chest.

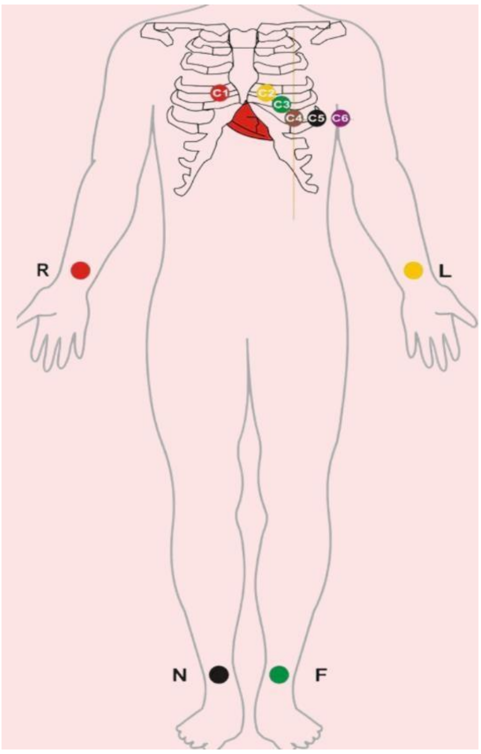


**Fig.2.1**. Electrode placement for ECG

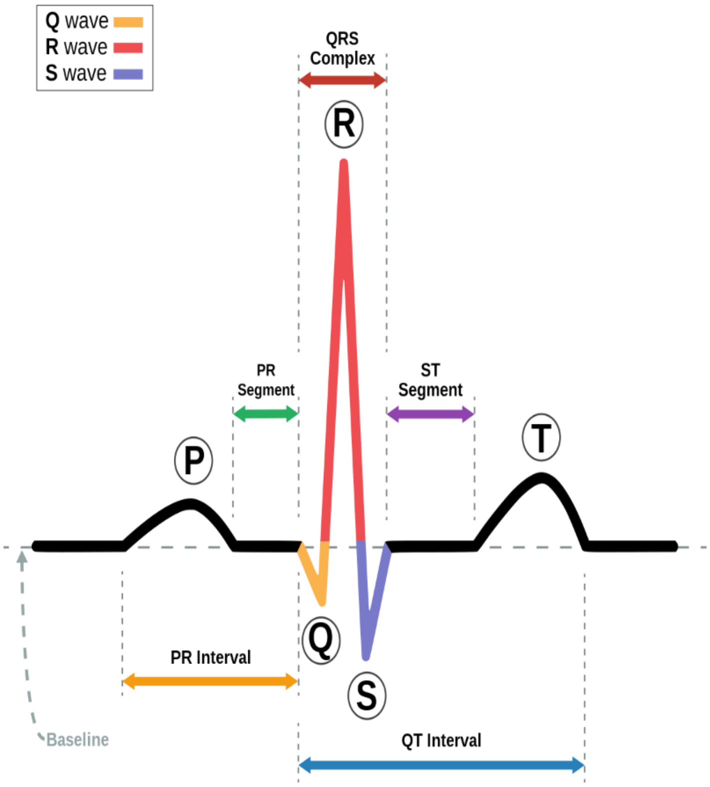


**Fig.2.2**. ECG signal

In the above ECG signal:

- The P wave represents atrial depolarization.
- The QRS complex represents ventricular depolarization.
- The T wave represents ventricular repolarization.
- The U wave represents papillary muscle repolarization.

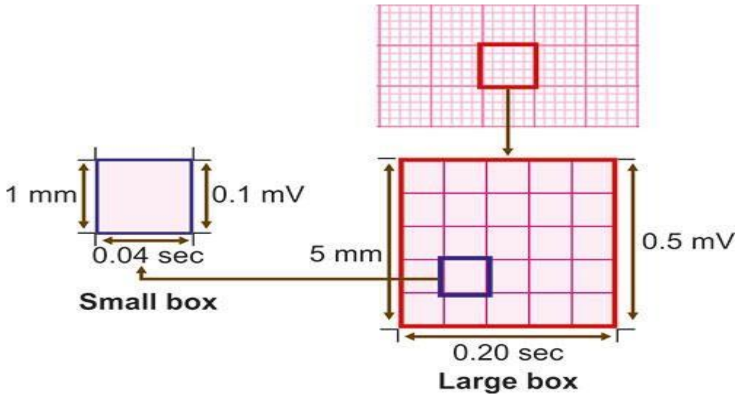


**Fig.2.3**. Scaling in ECG graph

Heart rate is calculated from the number of square boxes in between two R peak in the ECG signal. Typically, heart rate is measured with respect to 1 minute or 60 seconds.

So, 0.04 second=1 small box (horizontally)= 1mm

Then 60 seconds= 1500 small boxes

So the equation of heart rate is

$$\boldsymbol{HR} = \frac{\mathbf{60}}{\boldsymbol{t_{RR}}(\boldsymbol{seconds})} = \frac{\mathbf{1500}}{\boldsymbol{RR\ interval\ in\ mm}} = \frac{\mathbf{1500}}{\boldsymbol{No.of\ small\ box\ between\ two\ R\ peak}}$$

Where $t_{RR}$ = time between two R peak

The typical heart rate is 70-100 bpm for resting condition. In excited or active condition, this exceeds 140 most of the times.

## 2.4. Experimental Result:

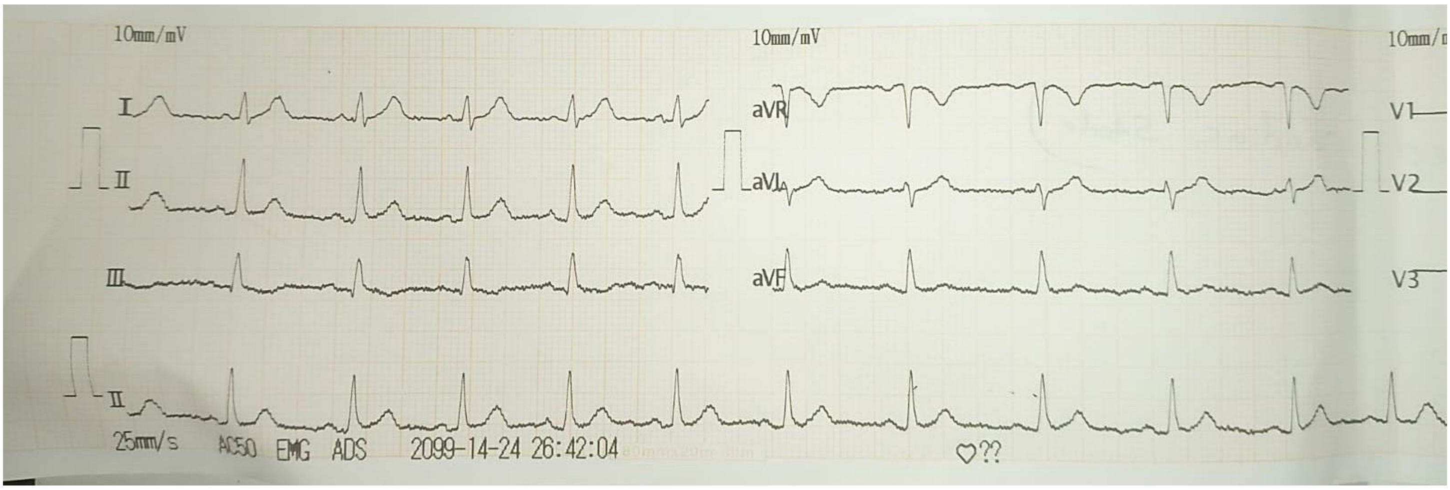


**Fig.2.4.** ECG signal before walking

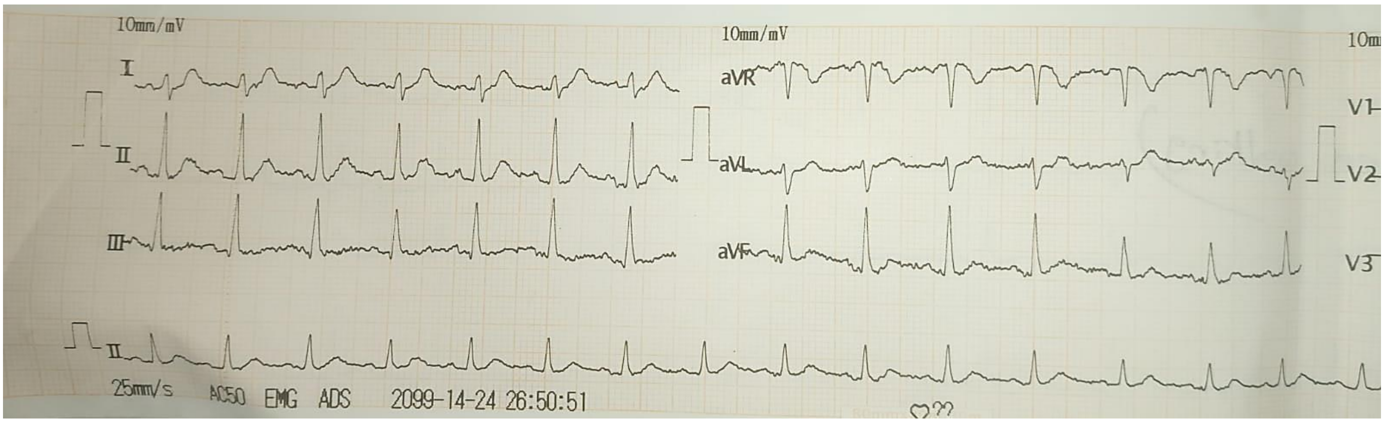

**Fig.2.5**. ECG signal after walking

## 2.6. Calculating Heart Rate:

i. Before walking:
R-R interval= 16 mm

So, Heart Rate = $\frac{1500}{17} = 88$

ii. After walking:
R-R interval= 12
So, Heart Rate =$\frac{1500}{11} = 136$

## 2.7. Discussion and Conclusion:

In this experiment, we performed the analysis of cardiac cycle in different state of heart. We performed the experiment before walking (resting condition) and after walking. In the resting condition, the R-R interval was more and heart was pumping moderately. So, according to the formula we got a moderate heart bit (88 bpm). But after exercise, the heart became excited and pumps faster than previous. Now the R-R interval decreases and heart rate increases (136 bpm). For different persons, the heart rates were not same but for all of them, heart rate increased largely after walking.

In this experiment, we took only the reading of 3 leads. The remaining 6 chest leads were absent here so their reading was not shown in the graph. If these readings were used, the graph would be more accurate.

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# Rajshahi University of Engineering & Technology

## Department of Electrical & Electronic Engineering

## LAB REPORT

**Course No** : EEE 4262

**Course Title** : Biomedical Engineering Sessional

**Experiment no** : 03

**Name of the Experiment:** Measurement the gain in an instrumentation amplifier circuit


**Submitted By**

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Section : B

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Assistant Professor,

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# Experiment No. 03

## 3.1 Experiment Name

Measurement the gain in an instrumentation amplifier circuit

## 3.2 Objectives

- To understand the basic principles and operation of an instrumentation amplifier
- To measure the differential gain in instrumentation amplifier

## 3.3 Theory

Instrumentation amplifiers are a specialized type of differential amplifier boasting exceptional common-mode rejection and high differential gain. Essentially, they amplify the difference between two input signals while simultaneously rejecting any common noise present in both.

This remarkable ability is achieved through a specific internal circuit configuration where a current, I3, flows through resistors R1, R2, and R3 based solely on the difference in voltage between the two inputs, Vi1 and Vi2. As a result, the output voltage differential, Vo1-Vo2, becomes directly proportional to this voltage difference, further amplified by a factor of (1+2(R1/R3)) and multiplied by the gain of the output stage (R6/R4).

## 3.4 Apparatus

- ❖ Multimeter
- ❖ Oscilloscope
- ❖ Resistor
- ❖ Potentiometer
- ❖ Op-amp
- ❖ Project Board
- ❖ Wires
- ❖ Signal generator

## 3.5 Data Table (Measured value)

| $V_{i1}$(volt) (p-p) | $V_{i2}$(volt) (p-p) | $R_3$ (Ω) | $V_o$ (volt) | Differential gain, $A_d = V_o/(V_{i1}-V_{i2})$ |
|---|---|---|---|---|
| 4 | 4.5 | 10k | 3 | 6 |
| 4 | 4.5 | 20k | 2.8 | 5.6 |
| 4 | 4.5 | 40k | 2.72 | 5.44 |
| 4 | 4.5 | infinity | 0.5 | 1 |

## 3.6 Calculated value

For $R_3$ = 10kΩ; $V_{i1}$ = 4 V; $V_{i2}$ = 4.5 V

$V_o$ = (1+2(10 /10)) (10/10) (4-4.5) = 1.5 V

$A_d = V_o / V_{i1}-V_{i2}$ = 1.5/ 0.5 = 3

For $R_3$ = 20kΩ; $V_{i1}$ = 4 V; $V_{i2}$ = 4.5 V

$V_o$ = (1+2(10 /10)) (10/10) (4-4.5) = 1 V

$A_d = V_o / V_{i1}-V_{i2}$ = 1/ 0.5 = 2

For $R_3$ = 40kΩ; $V_{i1}$ = 4 V; $V_{i2}$ = 4.5 V

$V_o$ = (1+2(10 /40)) (10/10) (4-4.5) = 0.75 V

$A_d = V_o / V_{i1}-V_{i2}$ = 0.75/ 0.5 = 1.5

For $R_3 = \infty$; $V_{i1} = 4$ V; $V_{i2} = 4.5$ V

$V_o = (1+2(10 / \infty))\,(10/10)\,(4-4.5) = 0.5$ V

$A_d = V_o / V_{i1}-V_{i2} = 0.5/ 0.5 = 1$

### 3.7 Discussion & Conclusion

The experiment successfully constructed the instrumentation circuit and accurately utilized a potentiometer as the gain resistor (R3). By varying the value of R3, different differential gains (Ad) were achieved, demonstrating its role in amplifying the differential input. While some discrepancies existed between the estimated and measured output, the observed decrease in Ad with increasing R3 aligned perfectly with theoretical predictions, validating the experiment's successful execution.

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# Rajshahi University of Engineering and Technology

**Course No.:** EEE 4262

**Course Title:** Biomedical Engineering Sessional

**Experiment No.: 05**

**Experiment Name**: Action Potential and bio electrical impedance measurement of human limbs

**Date of Experiment:** December 12,2023

**Date of Submission:** January 21,2024

| **Submitted By:** | **Submitted To:** |
|---|---|
| **Name**: Md Maruf Hassan<br>**Roll:** 1801105<br>**Section:** B<br>**Department:** Electrical & Electronic Engineering | Kusum Tara<br>Assistant Professor<br>Department of Electrical & Electronic Engineering<br>Rajshahi University of Engineering and Technology |

**Experiment No.: 05**

## 5.1 Experiment Name:
Action Potential and bio electrical impedance measurement of human limbs

## 5.2 Objectives:
a.To know about the action potential as well as the bio electrical impedance
b.To analysis the experimenta study about the bio electrical impedance in arm and leg

## 5.3 Required Apparatus:
a.Measuring electrodes
b. Bio-electrical impedance measurement device
c.Covering tape
d.Gel
e.Sample ( Human)

## 5.4 Theory:
An action potential occurs when the membrane potential of a specific cell rapidly rises and falls. This depolarization then causes adjacent locations to similarly depolarize. Action potentials occur in several types of animal cells, called excitable cells, which include neurons, muscle cells, and in some plant cells.

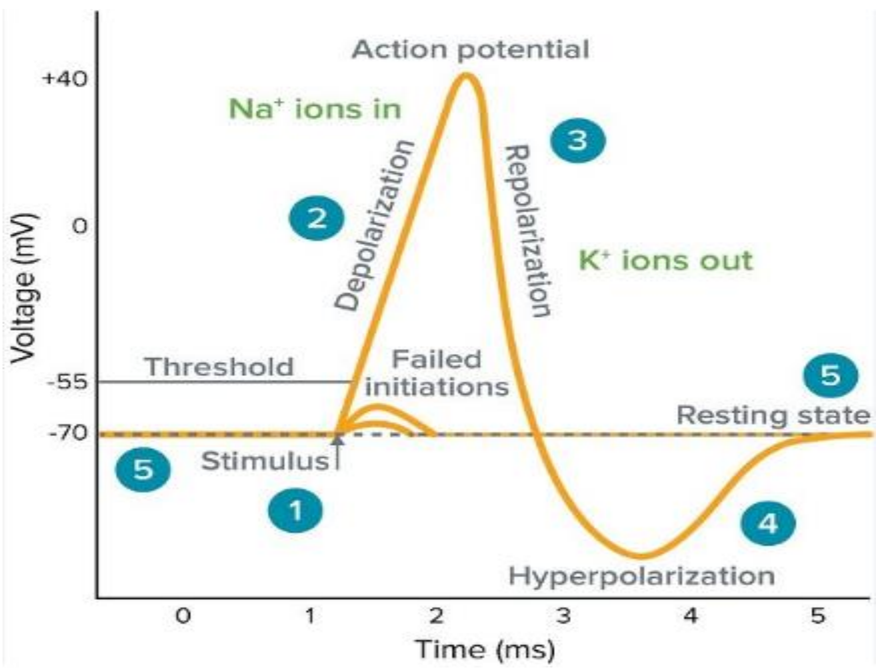


Fig. 5.1 Cell parameters (Voltage VS Time)

Bioelectrical impedance analysis (BIA) is a method for estimating body composition, in particular body fat and muscle mass, where a weak electric current flows through the body and the voltage is measured in order to calculate impedance (resistance and reactance) of the body. Most body water is stored in muscle. Therefore, if a person is more muscular there is a high chance that the person will also have more body water, which leads to lower impedance. Since the advent of the first commercially available devices in the mid-1980s the method has become popular owing to its ease of use and portability of the equipment. It is familiar in the consumer market as a simple instrument for estimating body fat. BIA [1] actually determines the electrical impedance, or opposition to the flow of an electric current through body tissues which can then be used to estimate total body water (TBW), which can be used to estimate fat-free body mass and, by difference with body weight, body fat.

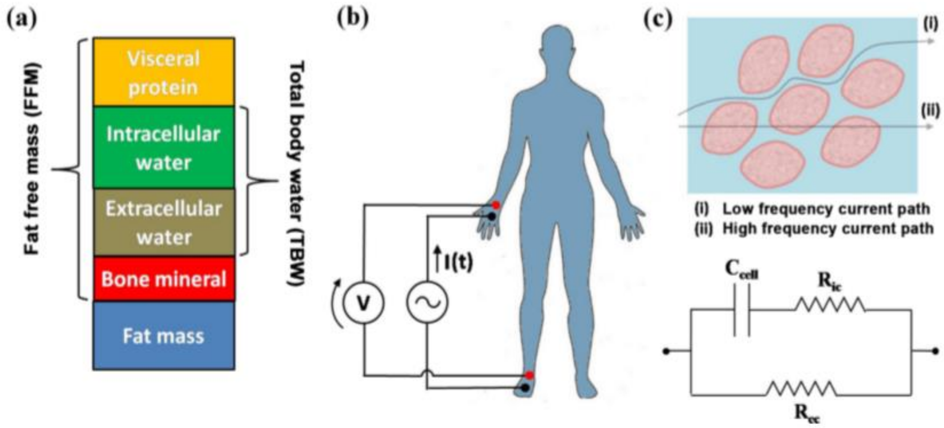


Fig.5.2 Bio-electric impedance measurement technique

### 5.5 Data Table & Calculation:

1.Shovo Ahmed

| Position | Impedance (Mega Ohm) | Voltage |
|---|---|---|
| RA-RW | 1.96 | 1.96 V |
| RA-LA | 1.75 | 1.75 V |
| RL-LL | 23 | 23 V |

[ Current injected= 1 Micro Ampere]

2.Noha

| Position | Impedance (Mega Ohm) | Voltage |
|---|---|---|
| RA-RW | 1.67 | 1.67 V |
| RA-LA | 1.86 | 1.86 V |
| RL-LL | 47 | 47 V |

[ Current injected= 1 Micro Ampere]

3. Forid

| Position | Impedance (Mega Ohm) | Voltage |
|---|---|---|
| RA-RW | 1.91 | 1.91 V |
| RA-LA | 1.89 | 1.89 V |

| | | |
|---|---|---|
| RL-LL | 41 | 41 V |

[ Current injected= 1 Micro Ampere]

4.Iftekhar

| Position | Impedance (Mega Ohm) | Voltage |
|---|---|---|
| RA-RW | 1.98 | 1.98 V |
| RA-LA | 1.56 | 1.56 V |
| RL-LL | 8 | 8 V |

[ Current injected= 1 Micro Ampere]

### 5.6 Discussion and Conclusion:

The experiment was about the action potential and bio impedance measurement in our body as right arm to left arm, arm to leg as well as leg to leg. Before doing the experimental analysis, a brief theoretical knowledge was acquired in this regard. The device that was used for the measurement, a constant 1 micro ampere current was injected through our body. The impedance that needs to check after 15s,30s, 60s for precise measurement. In this report, corresponding theory and data table is mentioned early. Negligible errors were neglected. However, the experiment was done properly.

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# Rajshahi University of Engineering & Technology

## Department of Electrical & Electronic Engineering

## LAB REPORT

**Course No** : EEE 4262

**Course Title** : Biomedical Engineering Sessional

**Experiment no** : 04

**Name of the Experiment:** Development of a MATLAB Based GUI App for Detection of Cardiac State

**Submitted By**

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