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Introduction to Biomedical Instruments

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ABSTRACT
This paper is mainly focused on Biomedical instruments , which are Basics of Medical Instruments, Block diagram of Medical Instrument. Biomedical signal processing aims at extracting significant information from biomedical signals. With the aid of biomedical signal processing, biologists can discover new biology and physicians can monitor distinct illnesses.
Keywords : Bioelectric signal, Block diagram, Microelectrodes

I. INTRODUCTION

Introduction to biomedical signals
Biomedical Instrumentation is the branch of medical science where the medical instruments are to be studied. Biomedical instruments are used to record, analyze & process the biomedical signals. Biomedical signals are extracting the information from biological systems like brain, muscles or heart etc, under investigation. The extracting information may be so simple to note the pulse rate of a person from wrist or so complex like analyzing the information from heart by using ECG. There are various sources for extracting signals from the biological system [1-2].

They are:
1. :-ECG (Electrocardiograph), EEG (Electroencephalograph), GSR (Galvanic Bioelectric signal skin response), EOG (Electrooculography) and EMG (Electromyograph) are the bioelectric signals. These signals are generated from the nerve cells or muscle cells. These signals are collecting from the cell membrane potential which may be excited under certain conditions to generate an action potential.
2. BioacousticSignals:-Lung sounds, heart sounds, bowel sounds, and joint sounds are the bioacoustic signals generated from the human body in easy and noninvasive way during its working.
3. Biochemical Signals:- Neurotransmitters are the chemical messengers from the body that control and regulate the body. These signals are extracted from the chemical measurement of living tissues & samples which are taken from living being.
4. Biomechanical Signals:- This signals are extracted from some mechanical function of the biological system. The flow of blood & pressure signals, all types of motion & displacement signals are the example of the biomechanical signals.
5. BiomagneticSignals:-MMG (Mechanomyogram) or MEG (Magneto-encephalogram) are the examples of biomechanical signals which are observed from the surface of muscles when it is contracted. Biomagnetic signals are obtained from the magnetic field produced

by electrical currents occurred naturally in the brain of the living things.

6. Bio-optical Signals:- Bio optical signals can observe either naturally or the signals may be introduced to measure a biological parameter with an external light medium.

7. Bio-impedance Signals:- An electrical impedance signal can be obtained due to the changes in blood volume or blood resistivity from human being.

The biomedical signals are extracted from the biomedical instruments. Therefore it is useful to study of biomedical instruments.

Basics of Medical Instruments:

Fig. 1.1.1 shows the general block diagram of Biomedical Instrument. The detailed descriptions of each block are as follows [3-5]:

1. Primary Sensing Element - The measurand is given to the primary sensing element where the conversion takes place. This is done by a transducer which converts the measured quantity into a usable electrical output. The transduction may be of any from such that mechanical, electrical or optical.

2. Variable Conversion Element - The output of the primary sensing element is in the electrical form and is suitable for control, record and display. But it may be necessary to convert this output to some other suitable form for preserving the original information. This function is performed by the use of variable conversion element. A system may require one or more variable conversion elements.

3. Variable Manipulation Element - The biomedical signals have very small amplitude. So it is necessary to manipulate the signal preserving the original nature of it. Thus the voltage amplifier is the example of variable manipulation element. The element that follows the primary sensing element in a measurement system is called signal conditioning element. The variable conversion element and variable manipulation element are jointly called as Signal Conditioning Element.

4. Data Transmission Element - The transmission of data from one circuit to another is performed by the data transmission element. In case of spacecraft, the control signals are sent from the control stations by using radio signals. The stage that follows the signal conditioning element and data transmission element collectively is called the intermediate stage.

5. Data Presentation Element - The readout or display devices which displays the required information about the measurand or measurement is called the data presentation element. The information of the measurement has to be monitor, control, and record for further analysis purposes. In case monitoring information, visual display devices are to be needed. For recording purpose, recorders like magnetic tapes, T.V equipment, and storage type CRT, printers, and so on are to be used.

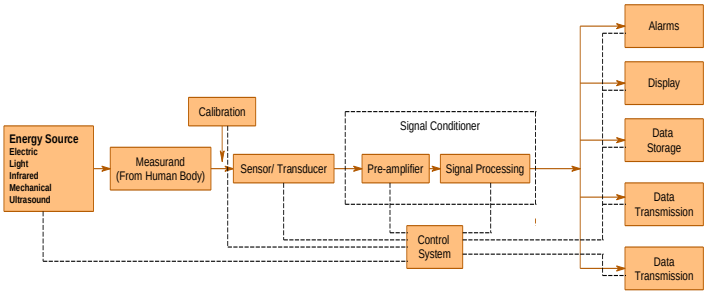

Figure 1 : General Block diagram of Medical Instrument

Biomedical signals are provided the information from biological systems under investigation. This is done by the use of excellent electrodes and powerful biomedical instruments having excellent signal to noise ratio. Therefore it is also necessary to study the recording electrodes used under the biomedical system.

Recording Electrodes used in the Biomedical Instrumentation:

Recording electrodesare the devices that convert ionic potentials into electronic potentials. The type of electrodes used for the measurements depends on the anatomical location of the organ. Bio-electrodes are the sensors that convert ionic conduction into electronic conduction. The purpose of bio-electrodes

is to acquire bioelectrical signals such as ECG, EMG, and EEG, etc.

Electrodes are mainly classified into two types [6]:

1. Perfectly polarized electrodes and
2. Perfectly non-polarized electrodes.

There are various electrodes that can be used to measure bioelectric signals. The three main classes of electrodes are Microelectrodes, Body Surface electrodes and Needle electrodes.

Microelectrodes

Microelectrodes are electrodes having fine tips to penetrate a single cell in order to obtain readings from the cell without damaging the nearby cells. The main function of microelectrodes is to obtain recording potential. Impedance of microelectrodes can play a very important role in the monitoring of low amplitude and high-resolution of the cells. Because of the smaller size of microelectrodes, it has high impedances in kilo ohms range.

It is classified into two types

a. Metal type

b. Micropipette type

a) Metal microelectrode:

Metal microelectrodes are prepared by electrolytic etching the tip of fine tungsten to the desired size and dimension. Then the wire is coated almost to the tip with any type of insulating material. The metal-ion interface takes place where the metal tip contacts the electrolyte. The main features of metal microelectrodes are

1. It has excellent signal to noise ratio
2. It is strong enough and easy to penetrate
3. It has high biocompatibility

b) Micropipette:

The micropipette type of microelectrode is a glass micropipette with its tip drawn out to the desired size. The micropipette is filled with an electrolyte which should be compatible with the cellular fluids. A micropipette is a small and extremely fine pointed pipette used in making microinjections. A commercial type of micropipette is shown in Fig. 1.1.2.

Figure1.1. 2:Micropipette type Electrodes

Body Surface Electrodes:

Body surface electrodes are placed in contact with the skin of the subject to obtain bioelectric potentials. Body surface electrodes are of many types and sizes. The various types of body surface electrodes are discussed below.

Major body surface electrodes are

a) Immersion electrodes:

In early years, these types of bioelectric measuring electrodes were used. These electrodes were simply buckets of saline solution in which the subject placed such as hands or feet. So it was not a comfortable type of measurement and hence it was replaced with the plate electrodes.

b) Plate electrodes:

These electrodes were separated from skin surface by cotton pads socked in a strong saline solution. These electrodes have generally smaller contact area. This type of electrodes has a tendency to lose their adhesive ability and therefore it causes errors in the result.

c) Floating electrodes:

These electrodes can eliminate the artifact errors which is a main problem with the plate electrodes. This is avoiding by making direct contact of the electrodes with the skin. So the main advantage of floating electrodes is mechanical reliable. The conductive path between the metal and the skin is the electrolyte paste or jelly.

d) Disposable electrodes:

Normally plate electrodes, floating electrodes etc can be used more than one time. But it requires more care while cleaning after each use. Thus uses of disposable electrodes are now very popular which can be disposed after the use.

e) Suction electrodes:

These electrodes are well suited for the attachment of flat surfaces of body and the regions where the underlying tissues are soft. These electrodes have a small surface area. These types of electrodes are mainly used for the measurement of ECG. Suction electrodes are shown in Fig. 1.1.3. It is used a plastic syringe barrel to house suction tubing and input cables to an AC amplifier.

Figure 1.1.3: Suction electrodes

f) Ear clip & Scalp electrodes:

These electrodes are widely used in the measurement of EEG. Scalp electrodes can provide EEG signals easily by placing it over the naked head. For measurement of EEG, it requires 10 – 20 electrodes and scalp electrode usually used. They can avoid measurement errors and movement errors. During labour, internal monitoring may be needed and usually fetal scalp electrodes are placed under the baby's scalp. It is also used to monitor baby's heartbeat while still in uterus. A typical ear clip and scalp electrodes are shown in Fig. 1.1.4.

Figure 1.1.4: Ear clips and scalp electrodes

g) Needle Electrodes:

To reduce the interface and artifact error which are arise due to the electrode movement, a small sub-dermal needle electrodes can be used for the measurement of EEG, EMG etc. Actually the needle electrodes are used to penetrate the skin of the scalp for measurement of EEG. Generally they are simply inserted through a small section of the skin just beneath the skin parallel to it.

The needle electrodes for EMG measurement consist of fine insulated wires placed in such a way that their tips are in contact with the muscles, nerve or other tissues. The needle creates the hole necessary for insertion and the wires forming the electrodes are carried inside it. A typical EEG needle electrode is shown in Fig. 1.1.5.

Figure 1.1.5: Needle electrodes

The main advantage of needle electrode is that it is less sensitive to cause error due to movement than the surface electrodes. Also the needle electrodes have lower impedances when compared to surface electrodes as it makes direct contact with the sub-dermal tissues or intracellular fluid [7].

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