Lectures Notes of Bio-Medical & Enviromental Instrument.

By Prafulla Kumar Panda

Generalised Biomedical instrumentation System 21/01/19

* Measurand.
* Sensor.
* Signal conditioning.
* Display.

22/01/19

The major difference between the biomedical and conventional instrumentation system is that the source of the signals is living tissue or energy applied to the living tissues.

Measurand:-

* The physical quantity property or condition is that the system measures is called measurand.
* The measurand is important because it may be internal (blood pressure). It may be on the body surface (ECG potential) or it may be derived from a sample i.e removed from the body.
* The most medically important measurands can be grouped on the following categories

i) Biopotential
ii) pressure
iii) Displacement
iv) Impedance
v) Temperature
vi) chemical concentration

Sensor:-

→ Generally the term transducer is defined as a device that converts one form of energy to another.

* A sensor converts a physical measurand to an electric output.
* The sensor should respond and interface with the living system in a way that minimizes the energy extracted.
* The many sensor have a primary sensing element such as diaphragm which convert pressure to displacement.
* A variable conversion element such as a strain gauge converts displacement to an electric voltage.

Signal conditioning:-

* Usually a sensor output can not be directly connected to the display device.
* Signal conditioning elements may amplify and filter the signal or match the impedan of the sensor to the display.
* The signal filtering may reduce undesirab sensor signals.

Output Display:-

* The results of the measurement process must be displayed in a form that a human operator can perceive.
* The best form for the display may be numerical or graphical or discreed.

The origin of Biopotential:-

*Engineering (engineers) generally have a good physical concept into the nature of electromagnetic field produced by Bioelectric sources and because of their compressive understanding of the physical problem they may contribute to the solution of Biological problems.

→ The Bioelectric potential are used as a result of electrochemical activity of a certain class of cells known as excitation cells that are components of nerves, muscular tissue and granular tissue.

→ Electrically they exhibit a resting potential and when appropriately stimulated an action potential generated.

→ The individual excitable cell maintain a steady electrical potential difference betn its internal and external environments.

→ This resting potential of the internal medium lies in the range -50 to -100mv relative to the external gain of the medium.

→ An axon or nerve fibre is a long projection of a nerve cell or neuron that typically conducts electrical impulses known as action potential, away from the nerve cell body.

→ The cell membrane is very thin (7-15nm) lipoprotene complex ie essentially impermeable to the intercellular protein. The membrane in the resting state is only slightly permeable to (Na^+) and a rather force K^+ & Cl^-.

→ The membrane in the resting state only slightly permeable to NA^+ and rather force to K^+ & Cl.

→ The permeability of the resting membrane to potasium (K^+) ion is approximately 50 to 100 times larger than this permeability to "Na^+" ion.

(4)

* For skelital muscle the K^+ concentration of the internal media is 140 mv/Letre where has that of the external media is 2.5 mv/litres. (2.5 m mol/ Litre)

* Thus the concentration in inbalance creats a diffusion gradient ie directed all toward across the membrane.

* The movement of the K^+ along this diffusion gradient is in such a direction as to make the interior of the cell more '-ve' relative to the outside of the cell.

* A transmembrane potential difference is thus eskablished as.

* The membrane may than be described electrically as a capacitore.

* That is it acts as a charge separaton that means it has a dielectric madercial.

* The electric field supported by the membrane capacitore and is directed inward from +ve to -ve across the membrane and it tends to outward flow.

* Thus the differential electrical process acting across the membrane and a steady state is ultimately achived.

(4)

28/01/19 Sources of Biomedical Signal (5)

Bioelectric Signal:-

It is unique in biomedical system. It is generally generated by nerve cells and membrane cells and to generate ac action potential (ECG).

Exp:- ECG.

Biomagnetic Signal:-

The various organs such as brain, heart and lungs produce extremly weak magnetic field. The measurement of these fields provides information not included in a other bio signals.

Exp:- Encephalogram.

Biomechanical Signal:-

The Biochemical signal includes the all signals used in biomedicine fields that originates from same mechanical system of biological system.

Exp:- motion and displacement signal.

Biochemical Signal:-

These signals are the results of the chemical measurement from the living tissues or from samples analized in the clinical lab.

Biooptical Signal:-

These signal are the results of the optical formation of the biological system.

Bioaquistic Signals :- (Bio-acoustic Signal) :-

Any biomedical phenomena creates an aquistic noise. The measurement of this noise provides information.

Exp :- The flow of blood through heart valves or blood vessels.

Exp :- contraction of muscles also creates noise.

Biomedical instruments :-

i) clinical instruments.
ii) Reserch instruments.

Clinical instruments :-

* Basically devoded diagnosis carried elements of patients and used by physicians and easy to handle the clinical instruments.

Reserch instrument :-

* Search for a new knowledge, related to human organism operated by skilled technologies.
* The more complex circuit than clinical instruments.

Intelligent medical instrumentation :- 29/01/19

(7)

→ Due to presence of high performance mp, mc & pc (personal computers) medical professional offers buffers intelligent and efficient monitoring management of the patient.

Use of ip in medical instrumentation :-

* more renewable and faster data to control logic sequence.
* By replacing programming devices as well as manual programming we can digitally conclude all the functions of medical instruments.
* Large data storage capacity to optimize the measurement condition.

Interfacing Analog signal to mp/mc :-

* The element are multiplexer, buffer, amplifier, sample and hold circuit, ADC, Tristate drivers and Data bus.

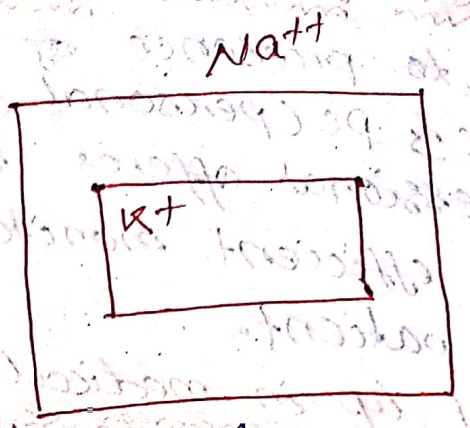
V.V.I PC based medical instrumentation.

General constrain in design of medical instrumentation system :-

(7)

(8)

(8)



* The ionic voltages produced as a result of the electro-chemical activity of certain special types of cells is known as bioelectric potential.
* It is generated as a cellular level and source is ionic in nature.
* Living tissue in human body acts as a power station which generates electric signal from two internal sources i.e muscles and nerves.
* The electrochemical charge during the conduction of signals along the nerves to or from the brain.
* The cell consists of an ionic conductor separated from outside environment by a semi-permeable membrane which acts as a selective ionic filter to the ions.
* Surrounding the cell body are body fluids. This fluids are conducting solutions containing charge electrons known as ions. The main ions are Na^+, K^+, & Cl^-.

* The membrane of the cell allows the entry of K^+ and Cl^- but blocks Na^+ ions because permeability of K^+ ions is too high as compared to Na^+ ions.
* The concentration of Na^+ is more outside the cell membrane, so outside of the cell is more '+ve' than inside.
* In order to balance electric charge, additional K^+ ions which are also '+ve' enters to the cell causing higher potential of the K^+ inside.
* Equilibrium condition is reached with the potential difference exists across the membrane i.e that means '-ve' on inside and '+ve' on outside.
* This charge distribution gives a certain electrochemical reaction and the process occuring within the cell is measured by a potential known as resting potential.
* Since it is measured from inside of the cell w.r.t body fluids, it is taken as '-ve' magnitude.
* The cell in such a condition is called polarised.
* The resting potential within a cell is approximately -19 mV.
* When a selection of cell membrane is excited externally by applying energy, the membrane changes its characteristics and begins to allow some of Na^+ ions to enter into the cell.

* Once the membrane is stimulated, all the sodium ions enters the membrane. (10)
* At the same time K+ ions which is at higher concentration inside the cell during resting state try to leave the cell, but are unable to move are rapidly as Na+ ions.
* So slightly +ve potential inside the cell due to impedance of 'Na+' ions. This potential is known as action potential.
* The cell in such a condition is said to be depolarised cell and process of conversion from resting to action is called depolarisation.

01/02/19

* once the equilibrium is reached, the ionic current, lowest the barriers to "Na+" are no more present and membrane comes back to its original condition.
* To attain a resting potential, it takes some time.
* By active process, the Na+ ions are quickly transferred to outside the cell and again it becomes polarised. This process is called repolarisation.
* The rate of pumping is proportional to Na+ ions in a cell.
* A cell may be caused to depolarise and then repolarise by subjecting the cell membrane to an ionic current unless a stimulus above a certain minimum value is applied. The cell will not be depolarised and no (10)

action potential is generated. This value is known as stimulus threshold.

* After a cell is stimulated, a finite period is required for the cell to restore to it's pre-stimulus state. The time taken for completion is known as refractory period.
* Energy associated with the action potential is developed from the metabolic process within the cell takes some time.
* Action potential is the difference between the potential of the depolarised membrane at the peak of action potential and the resting potential.