V V COLLEGE OF ENGINEERING

V V Nagar, Tisaiyanvilai

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

SOLVED UNIVERSITY QUESTIONS BANK

[QUESTIONS & ANSWERS]

Subject Code/Title : **OMD551 / Basics of Bio Medical Instrumentation**

Sem/Class : **III/ECE**

Staff Incharge's : **Mr.L.Amutha Swami Nathan, AP/ECE**

UNIT I BIO POTENTIAL GENERATION AND ELECTRODES TYPES

1. Draw the action potential waveform and explain the following terms – resting potential; absolute refractory period and relative refractory period. **(May/June 2011)**
2. Explain the origin of bio potential. **(May/June 2012) (Nov/Dec 2012)(May/June 2016)**
3. Discuss about the different types of electrodes used in Bio potential measurement. **(May/ June 2013) (May/June 2015) (Nov/Dec 2016) (May/June 2018)**
4. Discuss the events that generate Half cell potential across an electrode-electrolyte interface. Also, draw electrical equivalent circuit of the interface. **(Nov/Dec 2013) (May/June 2018)**
5. Mention any one method of half cell potential cancellation. **(Nov/Dec 2013)**
6. Discuss the different types of surface electrodes and its applications. **(Nov/Dec 2017)**

UNIT II BIO SIGNAL CHARACTERISTICS AND ELECTRODE CONFIGURATIONS

1. Discuss about the different EEG signal frequency bands. **(May/June 2011)**
2. Draw and explain the 12 lead system used in ECG.**(May/June 2011) (May/June 2013)**
3. **(May/June 2014) (May/June 2015) (Nov/Dec 2015) (May/June 2016) (Nov/Dec 2016) (May/June 2017) (May/June 2018)**
4. Compare the signal characteristics of ECG and EMG. **(May/June 2012)**
5. Draw the Bipolar lead system used in ECG and give its significances. **(May/June 2012)**
6. Explain the 10-20 electrode placement system used in EEG. **(May/June 2012) (Nov/Dec 2012) (May/June 2017) (Nov/Dec 2017)(May/June 2018)**
7. Draw a typical ECG waveform and mark the important features and the associated function of the heart.**(Nov/Dec 2012)**
8. Explain the measurement of EMG. **(May/June 2013)**
9. With neat diagrams, explain the schematic diagram of EEG machine. Also, show the recording method of unipolar and bipolar EEGs. **(Nov/Dec 2013)**
10. Explain the working of a multi-channel EEG recording machine.**(May/June 2015)**
11. With a neat diagram, explain the working of EMG systems and also give its typical waveforms that represent its signal characteristics. **(Nov/Dec 2015) (May/June 2017)**
12. List and discuss the characteristics and frequency bands of EEG signal.**(May/June 2016)**
13. Describe the typical recording setup of EMG.**(May/June 2016)**
14. Compare the signal characteristics of ECG, EMG, EEG and PCG. **(May/June 2018)**

UNIT III SIGNAL CONDITIONING CIRCUITS

1. What should be the characteristics of bio-potential amplifier? Explain with proper justification. **(Nov/Dec 2012)**
2. Distinguish a biological amplifier from a conventional amplifier with suitable equations and circuits. **(May/June 2014)**
3. List and discuss the important characteristics of bio amplifier.**(May/June 2017)**
4. With circuit diagram explain the instrumentation amplifier. **(Nov/Dec 2017)**

UNIT IV MEASUREMENT OF NON-ELECTRICALPARAMETERS

1. Explain the blood pressure measurement using following techniques
   (i) sphygmomanometer **(Nov/Dec 2015) (Nov/Dec 2016)** (ii) Ultrasonic **(May/June 2011) (May/June 2013) (Nov/Dec 2016)**
2. Explain the blood flow measurement using the following techniques: electromagnetic principle and thermo dilution. **(May/June 2012)**
3. Explain the working principle of electromagnetic blood flow meter. What are its advantages and disadvantages? **(Nov/Dec 2012) (May/June 2015) (May/June 2016) (May/June 2017)**
4. Explain fick's method for the determination of cardiac output.**(May/June 2013)**
5. Show the application of ultrasonic waves in measuring (i) Blood flow (ii) Blood pressure **(Nov/Dec 2013)**
6. Explain ausculatory blood pressure measurement.**(May/June 2015) (Nov/Dec 2017)**
7. Explain the function of a human respiratory system and the possible measurement and inferences made out of them. **(Nov/Dec 2015)**
8. Explain the measurement of respiration rate using impedance technique. **(May/June 2016)**
9. How the lung volume can be measured? Explain with necessary diagram. **(Nov/Dec 2016)**
10. Define the term “Cardiac Output”. How is cardiac output measured by dye dilution technique? Explain. **(May/June 2017)**
11. Explain the different methods of measurement of pulse rate. **(May/June 2018)**

UNIT V BIO-CHEMICAL MEASUREMENT

1. Explain the principle of following: pH measurement **(May/June 2016) (May/June 2018)** and auto analyzer **(May/June 2011) (Nov/Dec 2017)**
2. Explain the principle of following: photometer and autoanalyzer.**(May/June 2012)**
3. Explain the principle of operation of Coulter counter. What is its application? **(Nov/Dec 2012) (May/June 2016) (Nov/Dec 2017)**
4. With sketch explain how the PCO_2 of blood is measured. **(May/June 2015)**
5. Describe the measurement of PO_2. **(May/June 2017) (Nov/Dec 2017) (May/June 2018)**
6. Explain the block diagram and working of calorimeter. **(May/June 2017)**

UNIT I BIO POTENTIAL GENERATION AND ELECTRODES TYPES

1.Explain the origin of bio potential. (May/June 2012) (Nov/Dec 2012)(May/June 2016) (April /May 2019)

THE ORIGIN OF BIO-POTENTIALS:

- Bioelectric phenomenon is of immense importance to biomedical engineers because these potentials are routinely recorded in modern clinical practice.
- ECG (Electrocardiogram), EMG (Electromyogram), EEG (Electroencephalogram), ENG (Electroneurogram), EOG (Electro-oculogram), ERG (Electroretinogram), etc. are some examples of biopotentials.
- As engineers, we should have a good physical insight into the nature of electromagnetic fields generated by bioelectric sources. Therefore we could contribute to quantitative solution of biological problems.

To understand the origin of biopotentials we need to focus on:

- Bioelectric phenomena at the cellular level
- Volume conductor fields of simple bioelectric sources
- Volume conductor fields of complex bioelectric sources
- Volume conductor fields as a necessary link between cellular activity and gross externally recorded biological signals

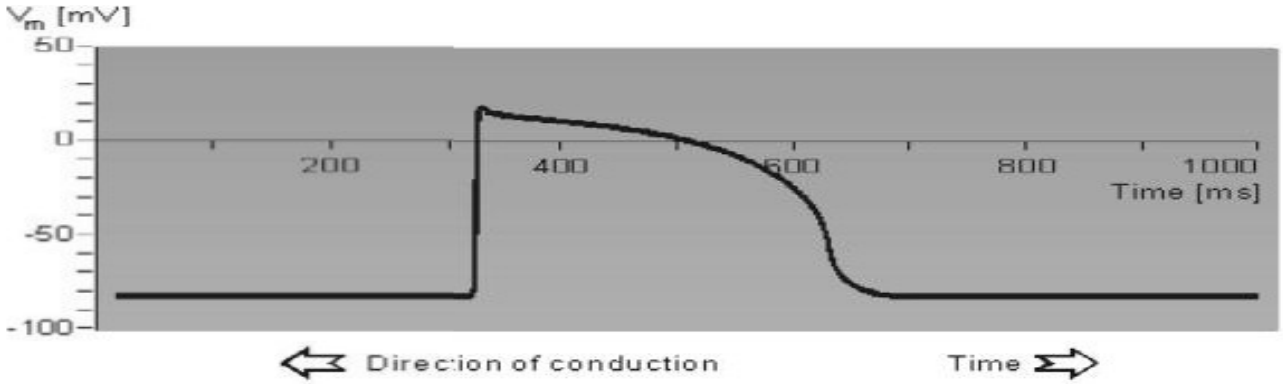
ELECTRICAL ACTIVITY OF EXCITABLE CELLS

Biopotentials are produced as a result of electrochemical activity of excitable cells: i.e., nervous, muscular (cardiac and smooth) and glandular cells

Factors influencing the flow of ions across the cell membrane

- Diffusion gradients
- Inwardly directed electric field (inside negative, outside positive)
- Membrane structure (availability of pores; K^+, $Na^+$and permeability of membrane to different ions)
- Active transport of ions across membrane against established electrochemical gradients
- When appropriately stimulated, they generate an action potential

BIOELECTRIC PHENOMENA AT THE CELLULAR LEVEL



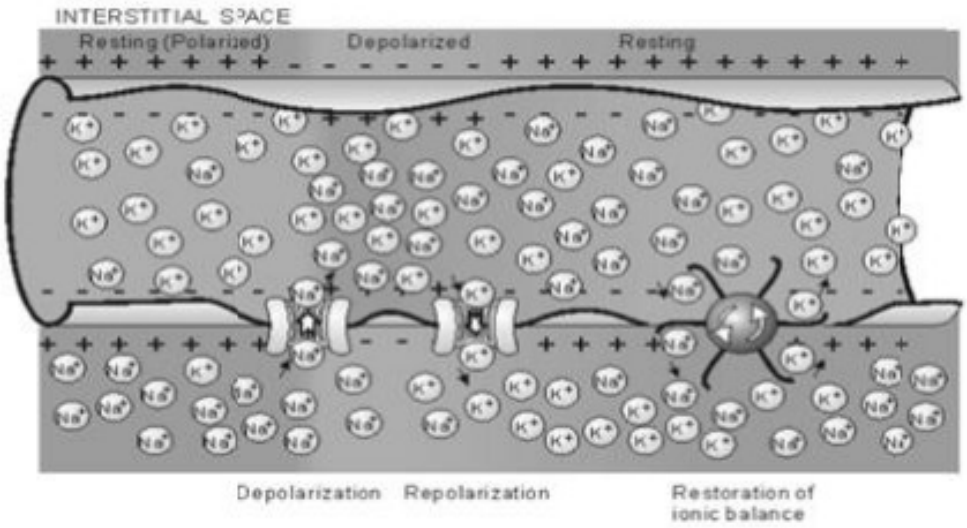


Fig. 1.1 Recording of action potential

A very important topic in electrophysiology is the relationship between intracellular and extracellular potentials, especially in nerve or muscle fibres .

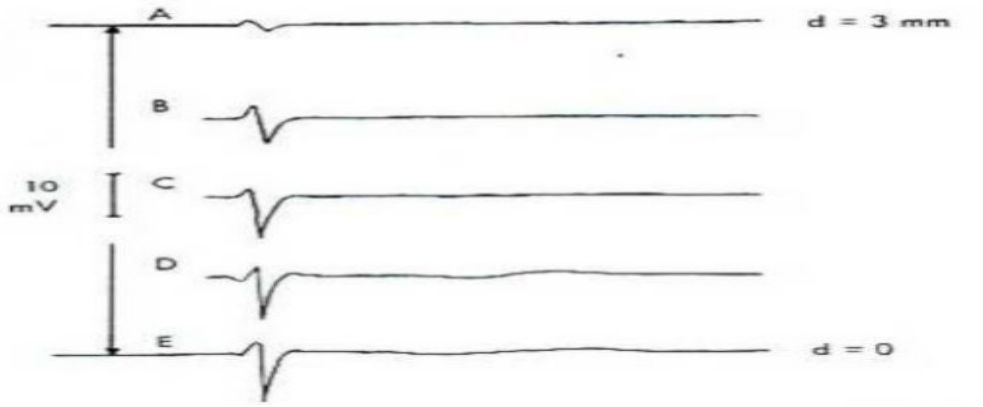


Fig. 1.2 Waveforms of intracellular action potential

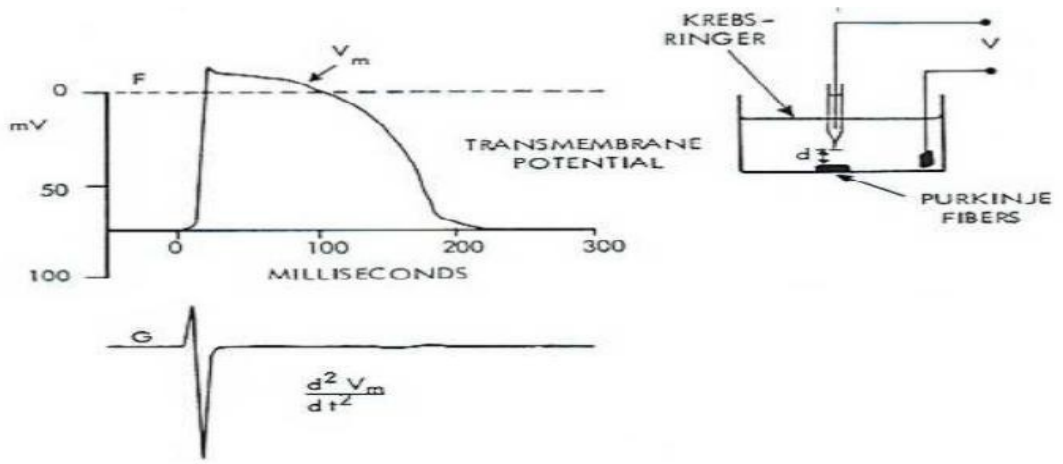


Fig. 1.3 Waveforms of Extracellular action potential

2.Discuss the different types of electrodes used in biopotential measurement (N/D2017,A/M2018,N/D2018)

BIOPOTENTIAL ELECTRODES

Electrode – Electrolyte Interface

General Ionic Equations

$C <-> C^{n+} + ne^-$

$A^{m-} <-> A + me^-$

- If electrode has same material as cation, then this material gets oxidized and enters the electrolyte as a cation and electrons remain at the electrode and circuit. flow in the external
- If anion can be oxidized at the electrode to form a neutral atom, one or two electrons are given to the electrode

The dominating reaction can be inferred from the following :

- Current flow from electrode to electrolyte : Oxidation (Loss of e-)
- Current flow from electrolyte to electrode : Reduction (Gain of e-)

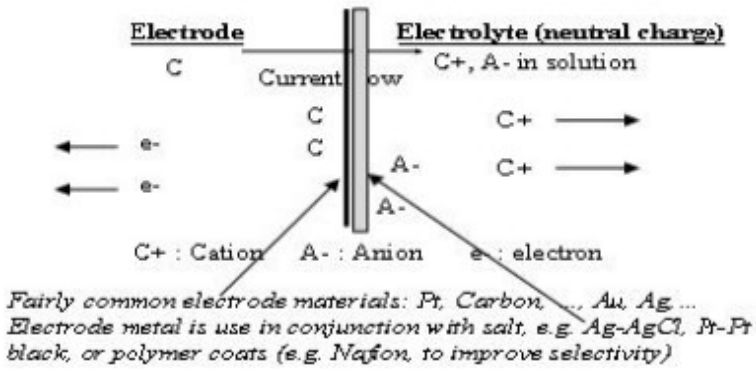


Fig. 1.5 Electrolyte Interface

Half Cell Potential

A characteristic potential difference established by the electrode and its surrounding electrolyte which depends on the metal, concentration of ions in solution and temperature.

Half cell potential cannot be measured without a second electrode.

- The half cell potential of the standard hydrogen electrode has been arbitrarily set to zero.
- Other half cell potentials are expressed as a potential difference with this electrode.

Reason for Half Cell Potential : Charge Separation at Interface

- Oxidation or reduction reactions at the electrode-electrolyte interface lead to a double- charge layer, similar to that which exists along electrically active biological cell membranes.

Measuring Half Cell Potential

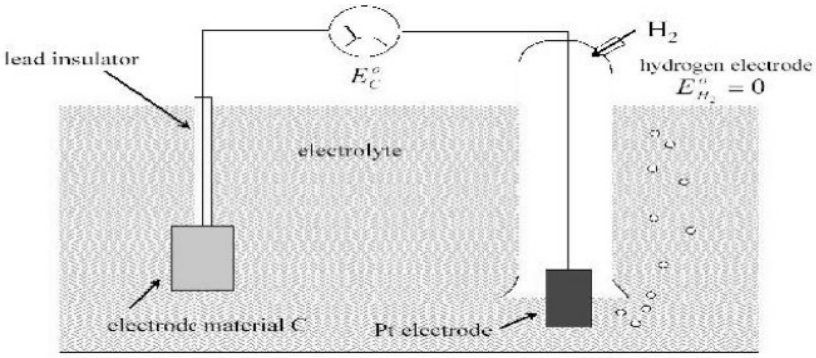


Fig. 1.6 Half Cell Potential

Polarization

- If there is a current between the electrode and electrolyte, the observed half cell potential is often altered due to polarization.

Nernst Equation

- When two aqueous ionic solutions of different concentration are separated by an ion- selective semi-permeable membrane, an electric potential exists across the membrane.

The Nernst equation for half cell potential is

$$E=E^0+RT/n[a_c\ a^d/a_A\ a_B]$$

where E0 : Standard Half Cell Potential
E : Half Cell Potential
a : Ionic Activity (generally same as concentration)
n : Number of valence electrons involved

Polarizable and Non-Polarizable Electrodes

Perfectly Polarizable Electrodes:

These are electrodes in which no actual charge crosses the electrode-electrolyte interface when a current is applied. The current across the interface is a displacement current and the electrode behaves like a capacitor. Example : Ag/AgCl Electrode.

Perfectly Non-Polarizable Electrode: These are electrodes where current passes freely across the electrode-electrolyte interface, requiring no energy to make the transition.

Over potentials. Example : Platinum electrode

Example: Ag-AgCl is used in recording while Pt is use in stimulation

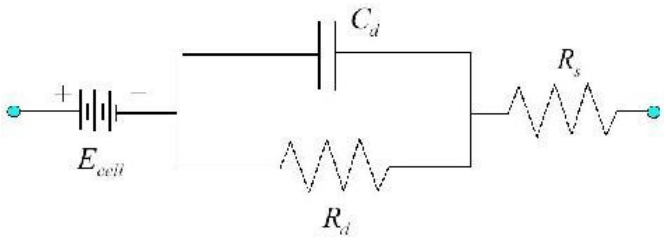


Fig. 1.7 Equivalent Circuit

Cd : capacitance of electrode-eletrolyte
interface *Rd* : resistance of electrode-eletrolyte
interface *Rs* : resistance of electrode lead
wire
Ecell : cell potential for electrode

Electrode Skin Interface
Motion Artifact

- When the electrode moves with respect to the electrolyte, the distribution of the double layer of charge on polarizable electrode interface changes. This changes the half cell potential temporarily.
- If a pair of electrodes is in an electrolyte and one moves with respect to the other, a potential difference appears across the electrodes known as the ***motion artifact.*** This is a source of noise and interference in biopotential measurements.Motion artifact is minimal for non-polarizable electrodes

Body Surface Recording Electrodes

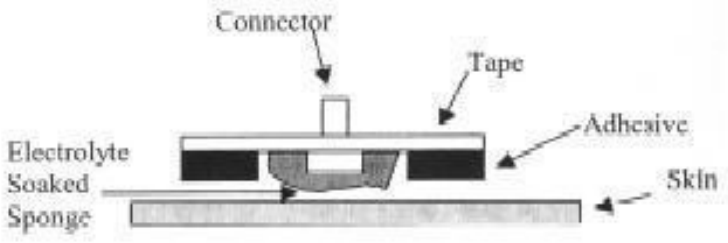


Fig. 1.8 Body surface Recording Electrodes

Commonly Used Biopotential Electrodes
Metal Plate Electrodes are

1. Suction Electrodes
2. Floating Electrodes
3. Flexible Electrodes

Metal plate electrodes

–Large surface: Ancient, therefore still used, ECG
–Metal disk with stainless steel; platinum or gold coated
–EMG, EEG
–smaller diameters
–motion artifacts
–Disposable foam-pad: Cheap!

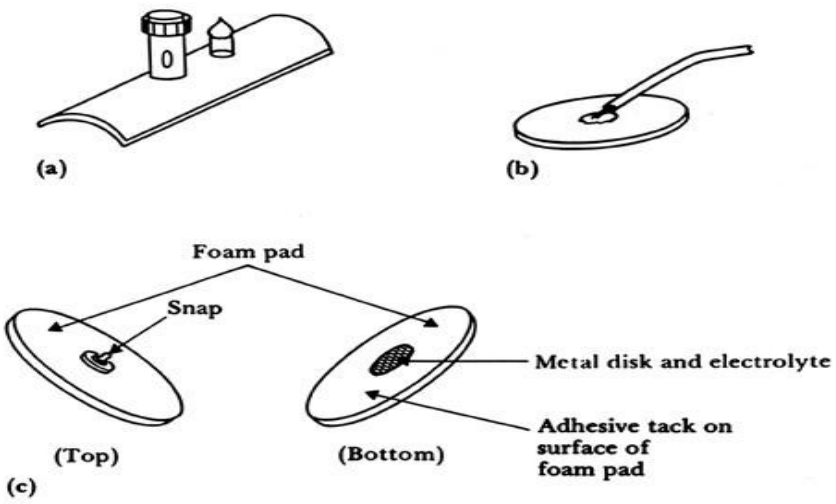


Fig. 1.9 Metal plate Electrode

Suction electrodes

-No straps or adhesives required
-precordial (chest) ECG
-can only be used for short periods

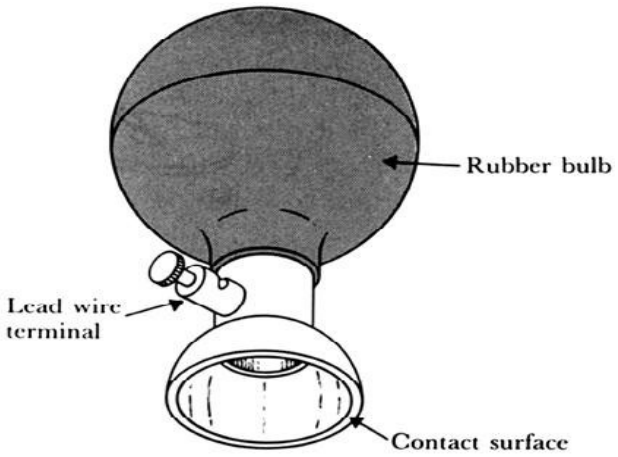
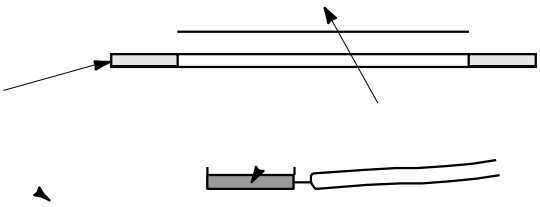
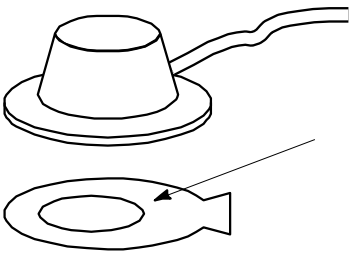


Fig. 1.10 Suction Electrode

Floating electrodes





Double-sided

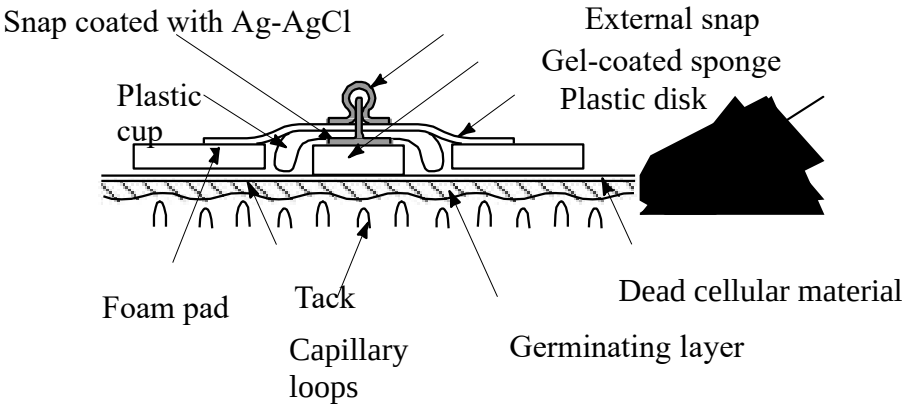
Adhesive-tape

ring

Electrolyte gel

in recess

(a) (b)



(c)

Fig.1.11Floating Electrodes

-metal disk is recessed
-not in contact with the skin
-reduces motion artifact

Flexible electrodes

-Body contours are often irregular
-Regularly shaped rigid electrodes may not always work.
-Special case : infants
-Material :
- Polymer or nylon with silver
- Carbon filled silicon rubber (Mylar film)

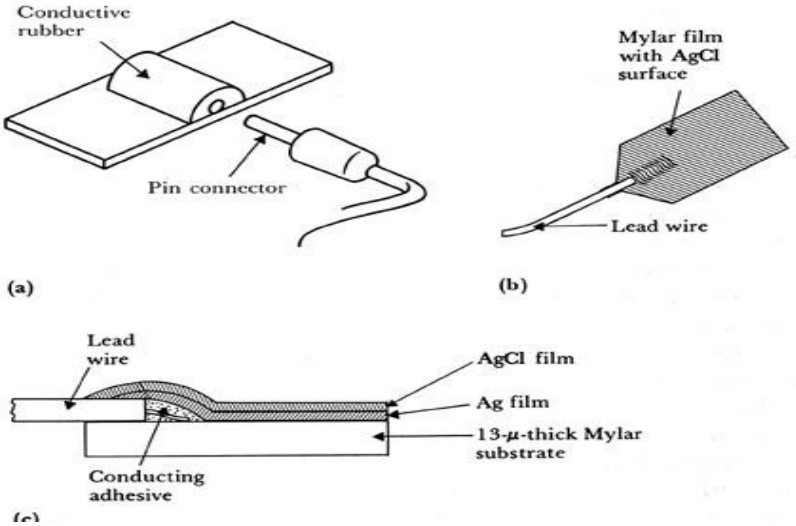


Fig. 1.12 Flexible Electrodes

(a)Carbon-filledsiliconerubberelectrode.
(b)Flexiblethin-filmneonatalelectrode.
(c) Cross-sectional view of the thin-film electrode in (b).

Electrodes in Biopotential Measurements

- •to make the electrode cheaper
- •more suitable for lower noise measurement for EEG
- •circumvent patents that are based on plastic/foam electrode body
- •attractive to consumers for use with their ECG machines at home
- •reduce artifact (minimize the motion of skin/electrode) in ambulatory recording

In a research laboratory, scientists want to record from single cells in a culture dish. They want to record action potentials from single, isolated heart cells. What kind of electrode would they need to use? Give a simplified schematic

Neural electrodes/microelectrodes

It is used to measure potential within asingla cell.It is small in diameter and during insertion of microelectrode into cell will not damage to human cell.

- •It is classified into
  1. Metallc
  2. Non metallic(Micropipet)

Metallic Electrode

- It is formed by electrolytically etching the tip of fine tungsten filament stainless wire into a minute structure.
- Potential within the cell can be measured by using two electrodes
  1. Micro electrode, 2. Reference electrode.

Non Metallic (Micropipet)

- It is used to measure the potential within the single cell using non metallic material is used.
- It is filled within an electrolyte ,that is compatible with the cellular fluids.

UNIT II BIO SIGNAL CHARACTERISTICS AND ELECTRODE CONFIGURATIONS

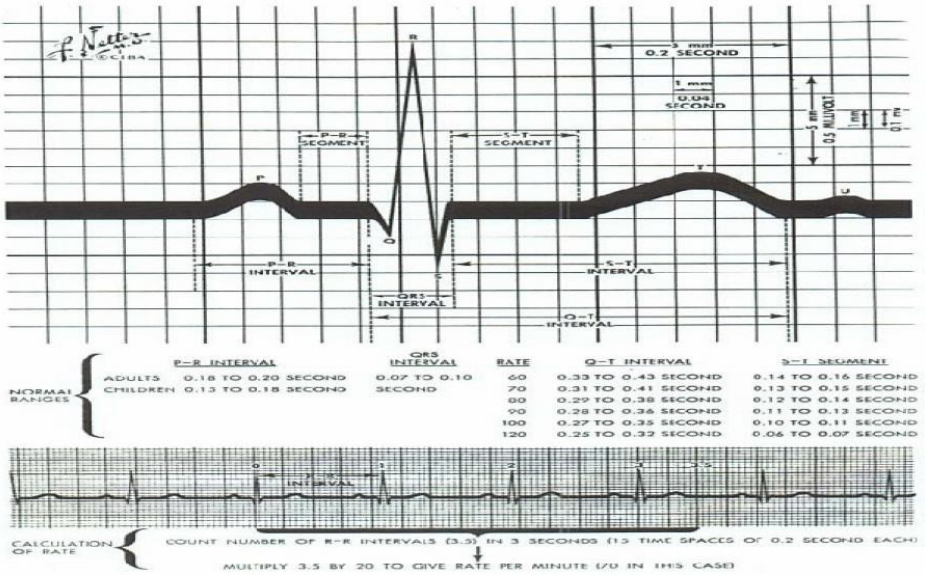
1.Draw and explain the 12 lead system used in ECG.(May/June 2011) (May/June 2013) (May/June 2014) (May/June 2015) (Nov/Dec 2015) (May/June 2016) (Nov/Dec 2016) (May/ June 2017) (April/May 2017)(Nov/Dec 2018)(April/May 2019)

- A very widely used medical instrument, which is utilized to diagnose and monitor cardiac beat abnormalities, is the electrocardiograph.
- It measures the electrical activity of the heart (more precisely biopotential differences arising from the electrical activity of myocardium). We've already talked about the genesis of the ECG signal.
- The ECG machine uses surface electrodes and high input impedance
- Differential amplifiers with good common mode rejection ratio to record the electrocardiogram
- Normal ECG amplitude ranges between 0.5-4 mV. Normal frequency content of ECG (for diagnostic purposes) is 0.05-100 Hz. A typical ECG waveform is shown below:

Significant diagnostic features of the ECG signal are:

- Duration of component parts of the signal
- Polarities and magnitudes
- The details of the ECG signal and the degree of variability in different parts of the ECG

signal is shown below:



ECG Signal

- The QRS amplitude, polarity, time duration, the RR interval (indicator of heartbeat per min.) and the T-wave amplitude are some very important and distinctive features of the ECG signal.
- The heart rate in BPM = Beats Per Minute) is simply = 60 (RR interval in seconds)

Some ECG waveform abnormalities that may indicate illness are:

- An extended PR interval may be diagnosed as AV node block

- A widening of the QRS complex may indicate conduction problems in the bundle of His
- An elevated ST segment may indicate occurrence of myocardial Infarction (MI)
- A negative polarity in the T wave may be due to coronary insufficiency

ECG Leads

A Normal ECG recording for the standard lead connections leads I, II and III (Lead II

provides the strongest signal)

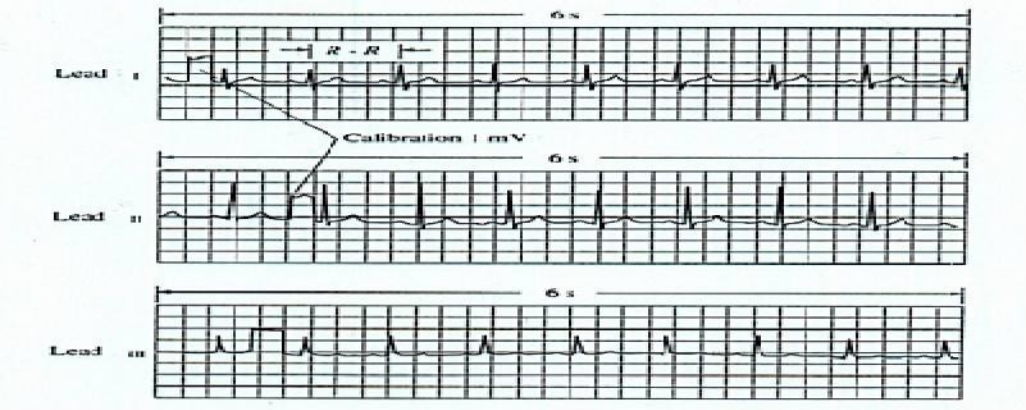


Fig. Normal ECG waveforms

Obviously, all human hearts are not the same and this results into a high degree of **variability.**

Some abnormalities that may indicate illness:

- An extended P-R interval may be diagnosed as AV node block
- Widening of the QRS complex conduction problems in the bundle of His
- Elevated ST segment may indicate occurrence of MI
- Negative polarity T wave may be due to coronary insufficiency QRS amplitude, polarity, time domain, PR interval (indicator of heat beat per min. & T-wave amplitude are some very important.

Distinctive features.

1.Loss

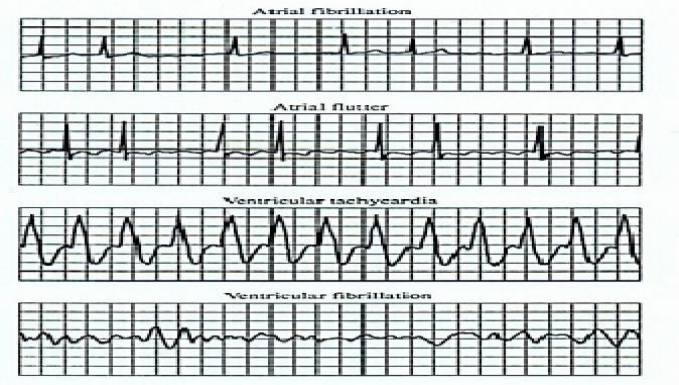
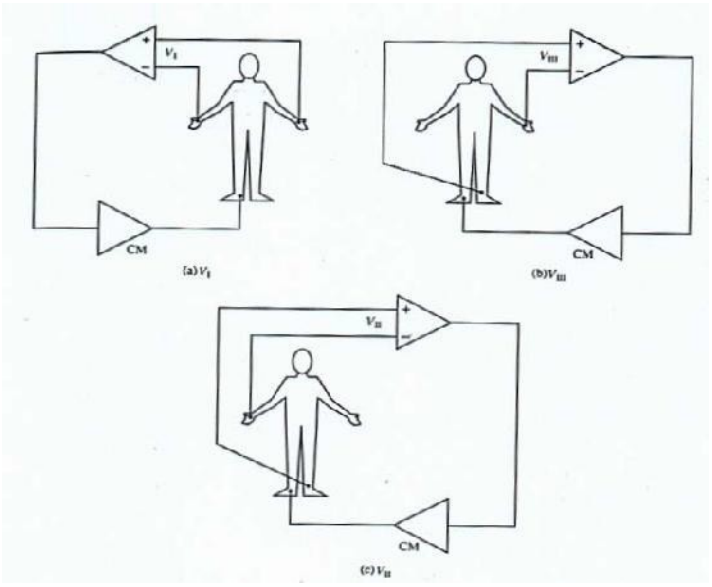


Fig. ECG Abnormal waveforms

2. Origin of the ECG signal

- We have already covered this concept extensively in the previous lectures (The Dipole filed of the heart, the Eindhoven's Triangle, the electrical circuit model for the electrocardiographic problem, etc.)

Standard Limb Leads (I, II, III)

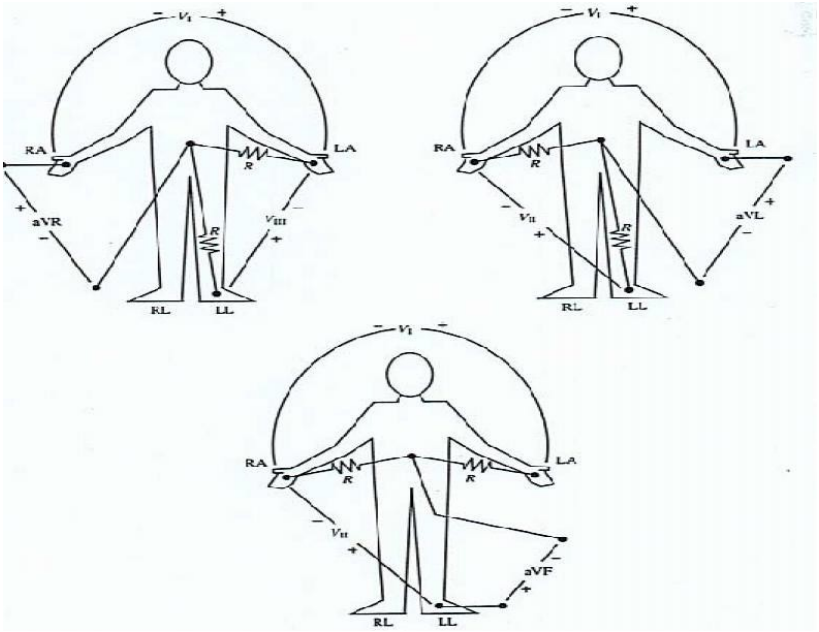


origin of ECG Signal

- The lead wires are color-coded according to some conventions. One example is: White – RA (Right Arm), Black – LA (Left Arm), Green – RL (Right Leg), Red – LL (Left Leg), and Brown – C (Chest)

Augmented Limb Leads

- These leads offer a free 50% increase over leads VR, VL, and VF connections (unipolar leads) with respect to Wilson terminal AVR = -I – III/2, AVL = I – II/2, aVF = II – I/2



Augmented Limb Leads

Each measurement is made from the reflected limb and the average of the other two limbs.

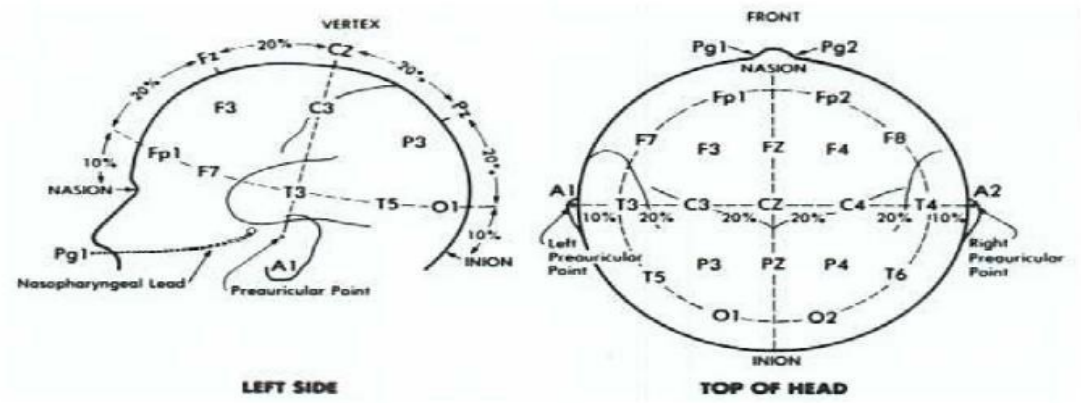
The ECG Machine

Most representative Specs:

- Zin = 10 MΩ
- Frequency response = 0.05 –100 Hz
- Strip Chart Recorder Speed = 25 mm/sec.
- **Fast Speed = 100 mm/sec.**

2.Explain the 10-20 electrode placement system used in EEG. (May/June 2012) (Nov/Dec 2012) (Nov/Dec 2017)(April/May 2017)(Nov/Dec 2018)(April/May 2018)

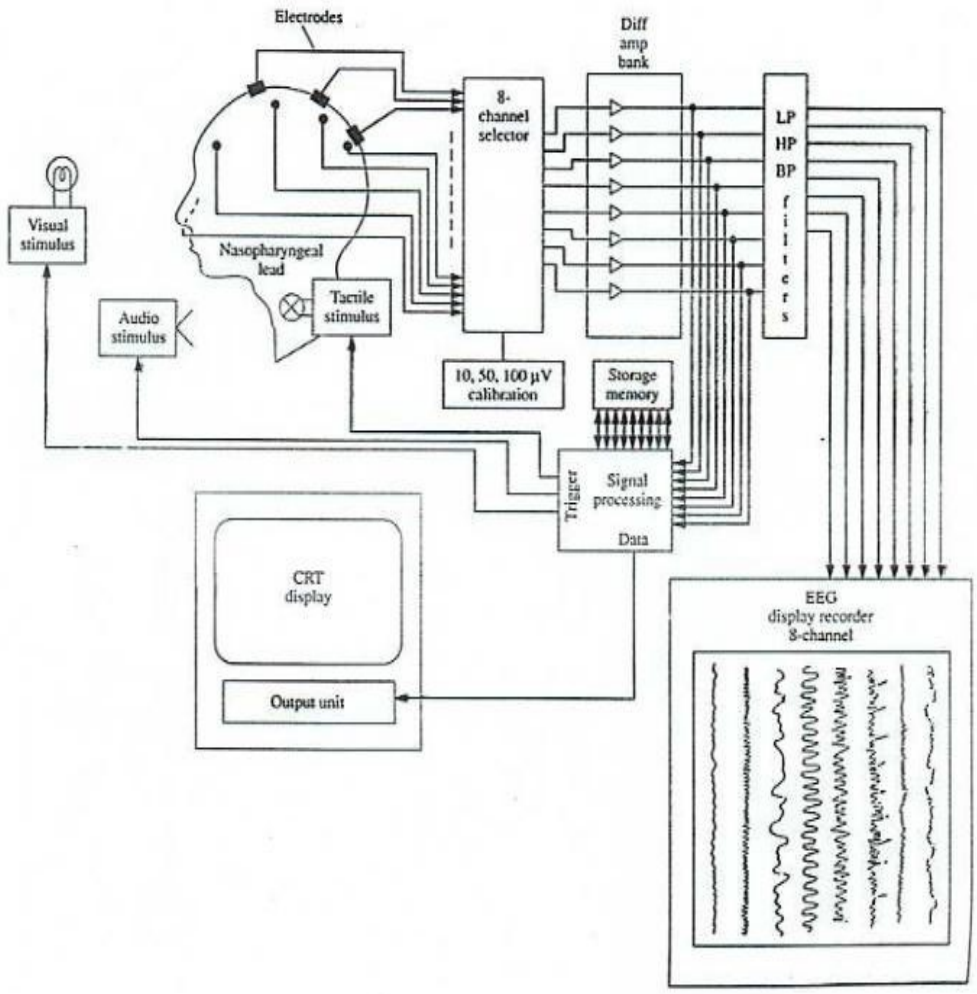
- In electroencephalography, the electrodes are placed in an arrangement referred to as the
  10-20 system.
- This is a placement scheme devised by the International Federation of Societies of
  Electroencephalography
- The electrodes are placed along a line drawn on the skull from the root of the nose, the nasion, to the classification (bump on the occipital lobe)
- The first mark is placed 10% of the distance along this line and others are arranged at
  20% intervals



EEG Electrode position

Electroencephalograph Signal Path

The EEG signal path is comprised of: Scalp (biosignal source) EEG electrodes , Junction box ,channel selector , differential amplifier, bank filters, display .



Block diagram of Electroencephalograph Signal Path

- It shows the modern 8 channel EEG recorder. The patient cable consists of 21 electrodes and is connected to the 8 channel selector.
- The electrodes are attached to the channel selector in groups of 8 called a montage of electrodes.
- The right ear electrode acts as reference electrode for the right brain electrodes and left ear electrode act as reference electrode for left brain electrodes.
- The 50 Hz interference is reduced by employing differential amplifiers as preamplifiers with more than 80 dB CMRR and by use of 50 Hz notch filters.
- The effect of notch filter on signal distortion is not so much because important EEG
- signals have frequencies below 30 Hz.
- The output voltage from the amplifier may either be applied directly to the eight channel display through the filter bank or it may be stored as data on a tape recorder or in a computer memory for further processing.

EEG is recorded with 3 types of electrodes:

1. Scalp
2. Cortical Electrocardiogram (recording from surface of cortex)
3. Depth Electrodes recording from depth of brain (thin insulated needles of various designs)

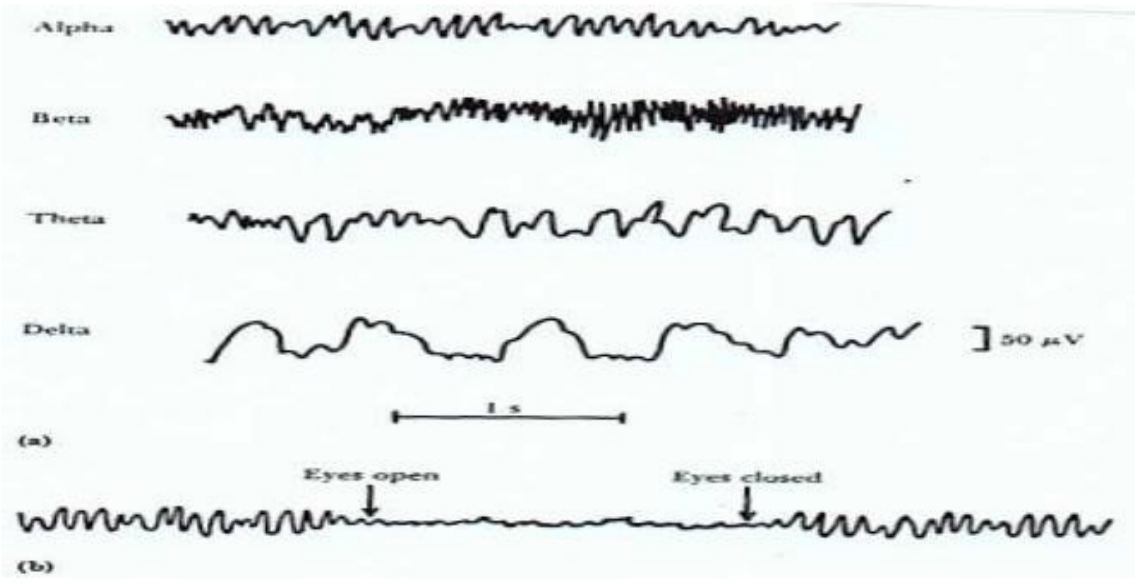
- No matter where the recording is obtained from (scalp, cortex or depth of the brain), the fluctuating potentials represent a superposition of the volume conductor fields produced by a huge variety of active neuronal current-generators.
- On the surface of the brain (i.e. Electrocardiogram), we can record voltages on the order of 10 mV! But, typical EEG electrodes measure the electrical activity propagated through skull bone and is attenuated from 1 to 100 μV.
- EEG potentials vary as a function of position over the surface of the skull, making it necessary to select sets of electrodes grouped around Frontal, Parietal, Temporal and Occipital lobes.

The EEG Signal

- The character of the EEG signal is highly dependent on the degree of the activity of the cerebral cortex, i.e. waves change markedly between states of wakefulness and sleep.
- Much of the time, EEGs are irregular and no general pattern can be observed. Other times, distinct patterns emerge
- The EEG waveform is divided into four wave groups:
    - The Alpha Waves (α) 8-13 Hz
    - The Beta Waves (β) 14-30 Hz (The Gamma Waves (γ) 22-30 Hz or higher)
    - The Theta Waves (θ) 4-7 Hz
    - The Delta Waves (δ) <3.5 Hz

Note: During periods of mental activity, the waves usually become asynchronous rather than synchronous, so the magnitude of summed potentials decreases in spite of cortical activity.

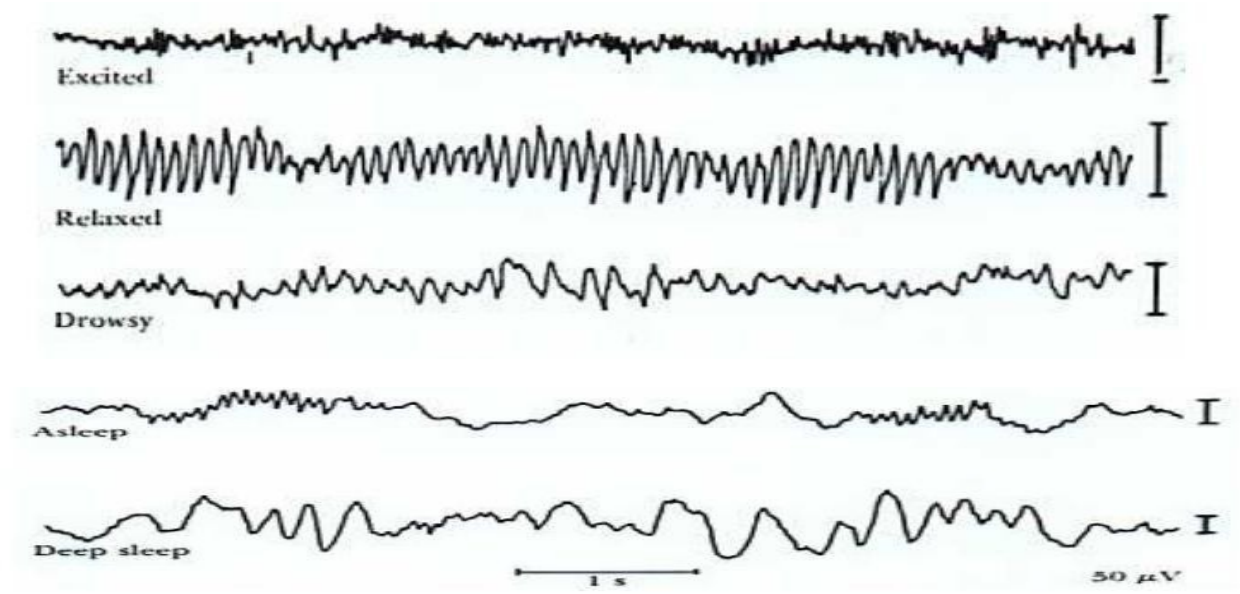
- In general there is a relationship between cerebral activity and the frequency of the EEG
  rhythm
- Frequency increases progressively with higher degrees of activity



EEG waveform

Examples:

- δ-Waves(<3.5 Hz) occur in surgical anesthesia and sleep
- θ-Waves(4-7 Hz) occur in emotional stress and frustration
- α-Waves(8-13 Hz) occur during relaxed states
- β-Waves(14-30 Hz)occur during intense mental activity



Different EEG waveforms

The EEG changes that occur as a human subject goes to sleep.

EEGs in Diagnosis

The purpose of the clinical EEG is to help neurologists diagnose disease. The pathological states most commonly diagnosed using EEG are:

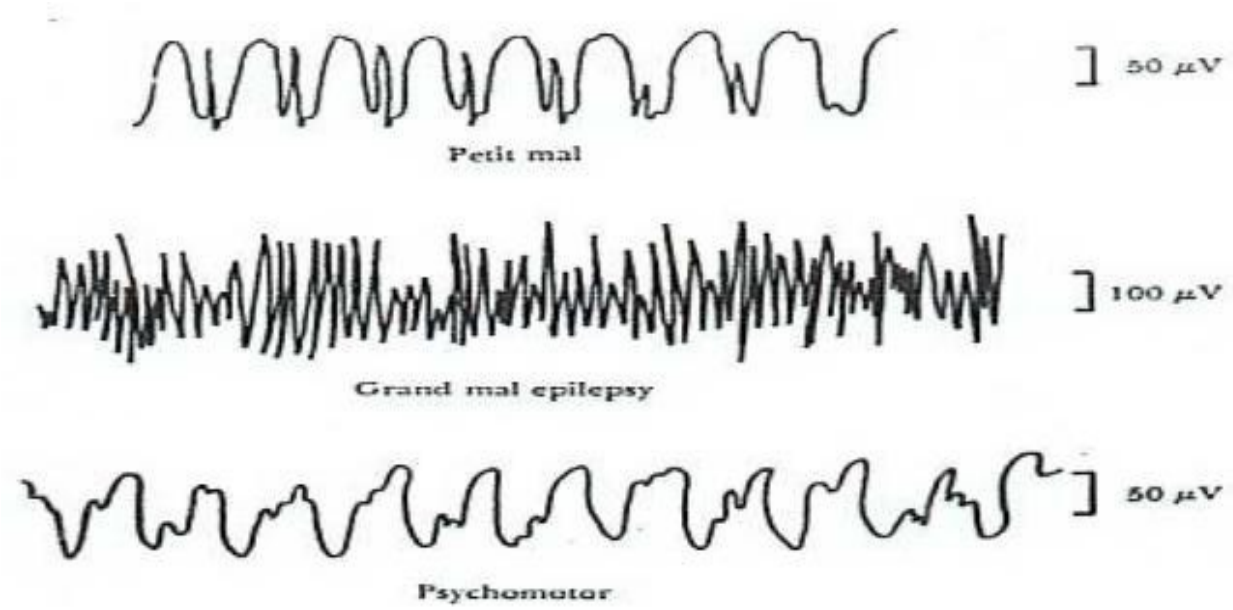
- Brain death (legal death)
- Brain tumors
- Epilepsy
- Multiple Sclerosis
- Sleep Disorder
- Evoked responses (diseases of the audio, visual and tactile senses)
- Modern life sustaining equipment like respirators, kidney dialyzers, ventilators, artificial heart pumps have changes the definition of death
- A sustained absence of EEG signal is a clinical measure of brain death and can be used in deciding whether to transplant a heart, liver, or lung or whether to shut down the life sustaining equipment

Some Representative Abnormal EEGS

Petit mal epilepsy– Minor for of seizure, clouding of consciousness and loss of contact with the environment

Grand mal epilepsy– Sudden loss of consciousness, falling down, tonic contractions (stiffening of muscles) followed by twitching and jerking movements of the limbs

Psychomotor seizures are parietal seizures characterized by: semi-purposeful movements, changes in consciousness, hallucinations and illusions.



3.**With a neat diagram, explain the working of EMG systems and also give its typical waveforms that represent its signal characteristics. (Nov/Dec 2015) (May/June 2017)**

EMG (ELECTRO MYOGRAPH)

It is an instrument used for recording the electrical activity of the muscles to determine whether the muscle is contracting or not. Study of neuromuscular function is also possible by using EMG. Muscular contractions are caused by the depolarization of muscle fibers. Similarly the recording of peripheral nerves action potentials is called as electro neurography.

ELECTRODES USED FOR

EMG Two types of electrodes:

Surface electrodes- Usually this electrode is used for EMG. But by using this electrode, it is not possible to take the deeper potential.

Needle electrodes – These are inserted into tissue or closer to tissue to measure the electrical activity of muscle.

EMG RECORDING SYSTEM

EMG potentials are taken from the tissue by using electrodes. These EMG potentials are given to differential amplifier. This is the high gain amplifier. Its frequency range is given as 10
Hz to 10 KHz.

Bandwidth of EMG is large. CMRR (Common mode Rejection Ratio) of this differential amplifier is 80 to 100 db.Input Impedance of this amplifier is 10 MΩ. Here there is no lead selector switch. Because only two electrodes are available. The output of the differential amplifier is given to loudspeaker system, tape recorder and CRO.

Before giving the output of differential amplifier to loudspeaker, it is given to power amplifier. Power amplifier amplifies the signal that is received by loudspeaker.

The amplified signal from the output of the differential amplifier is displayed by using CRO. Here storage oscilloscope is used. Output cab be displayed and the same can be stored in the CRO. The signal from the differential amplifier is recorded by using tape recorder. It is used for the future purpose.

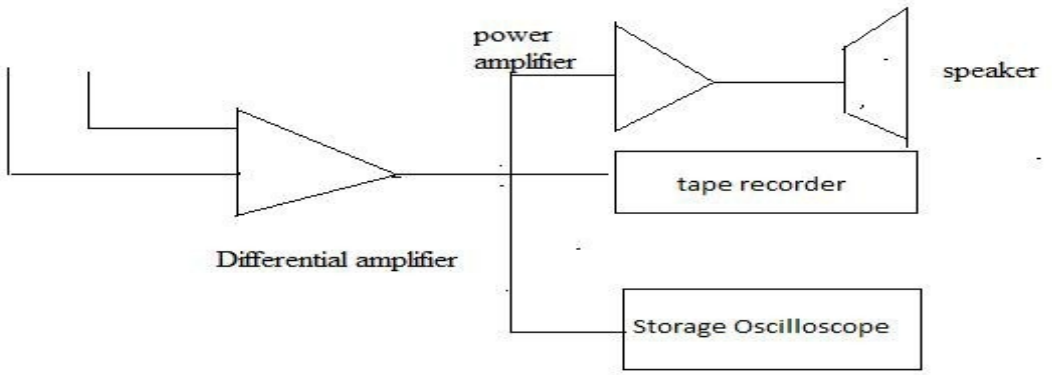


Fig. 1.29 EMG Recording System

MEASUREMENT OF CONDUCTION VELOCITY IN MOTOR NERVES

In modern EMG systems, nerve conduction time and nerve velocity are measured. For this measurement, initially nerve is stimulated and EMG is measured.This conduction velocity measurement is used to indicate the location and type of nerve lesion.

Steps involved in measurement of conduction velocity

- Stimulate is applied at point A
- Electrical activity of muscle is measured at point B
- The space between A and B is noted as l_1 meters.
- The time delay between applying stimulus and receiving action potential is known as latency. This time delay is detoned as t_1 second.
- Now change the position of A into C. Now the space is reduced. It is noted as l_2 meters.
- The time delay noted is t_2 second.
- Usually, $l_2 < l_1$ and $t_2 < t_1$.
- Now , the conduction velocity is given as , $V = l_1 - l_2 / t_1 - t_2$.
- Usually V= 50 m/sec.
- If V<40 m/s. It means there is some disorder in nerve conduction.
- Thus conduction velocity is measured in motor nerves.
- Skeletal muscle is organized functionally on the basis of the motor unit.

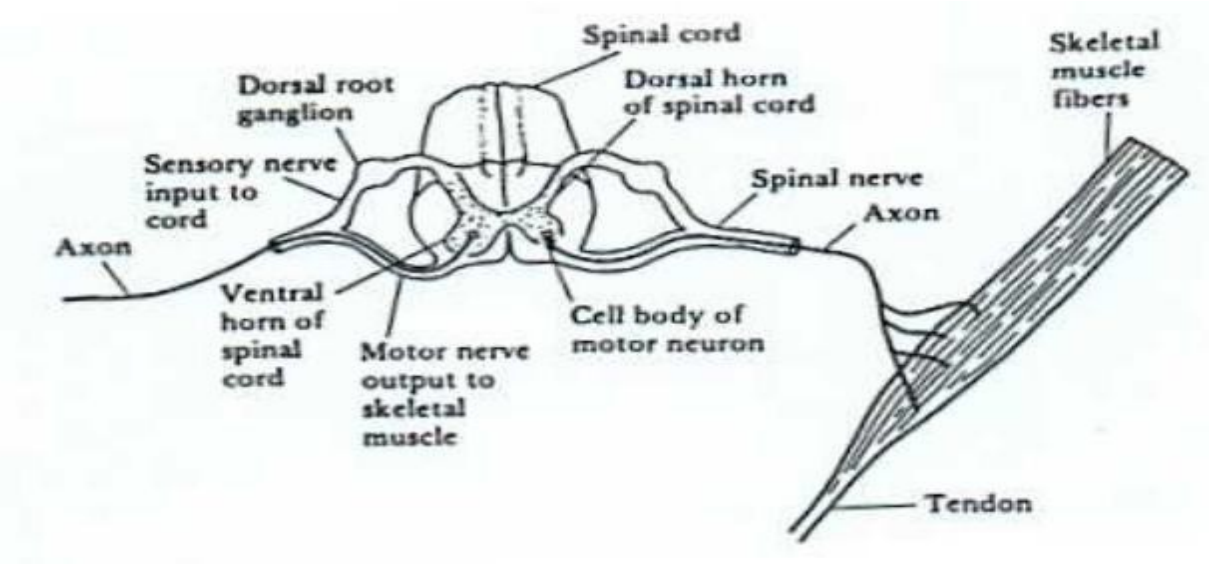


Fig. 1.30 Conduction Velocity In Motor Nerves

Single Motor Unit (SMU)

- The motor unit is the smallest unit that can be activated by a volitional effort (all constituent muscle fibers are activated synchronously)
- Single motor unit (SMU) consists of a single motor neuron and the group of skeletal muscles that it innervates
- SMU is a distributed unit bioelectric source in a volume conductor consisting of all other muscle fibers, both active and inactive.
- The evoked extracellular field potential from the active fibers of an SMU has a triphasic form of 3-15 ms duration and 20-2000 μV amplitude depending on the size of SMU
- The figure below shows motor unit potentials from normal muscle under graded levels of contraction. At high levels of activity, many sophisticated motor unit responses give rise to a complicated response (interference pattern)

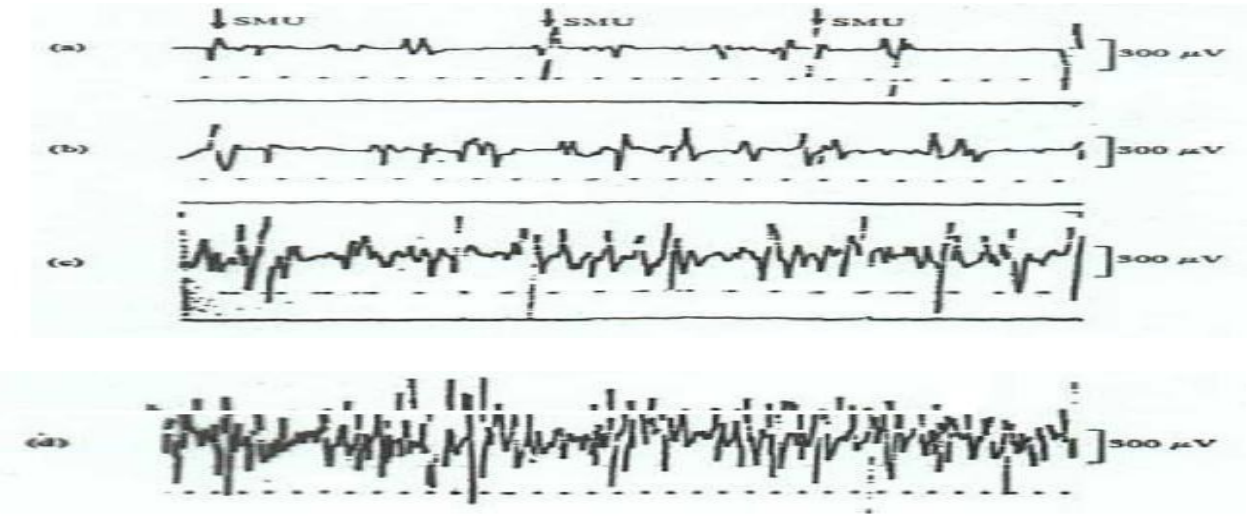


Fig. 1.31 EMG Recording

A variety of electrodes have been developed for EMG recording

- The figure below shows the needle and wire electrodes used in recording the EMG signal

- The EMG is also of considerable clinical value
- The shape of SMU potentials is modified by disease

The figure below shows the EMG response for a normal subject and one with neuropathy

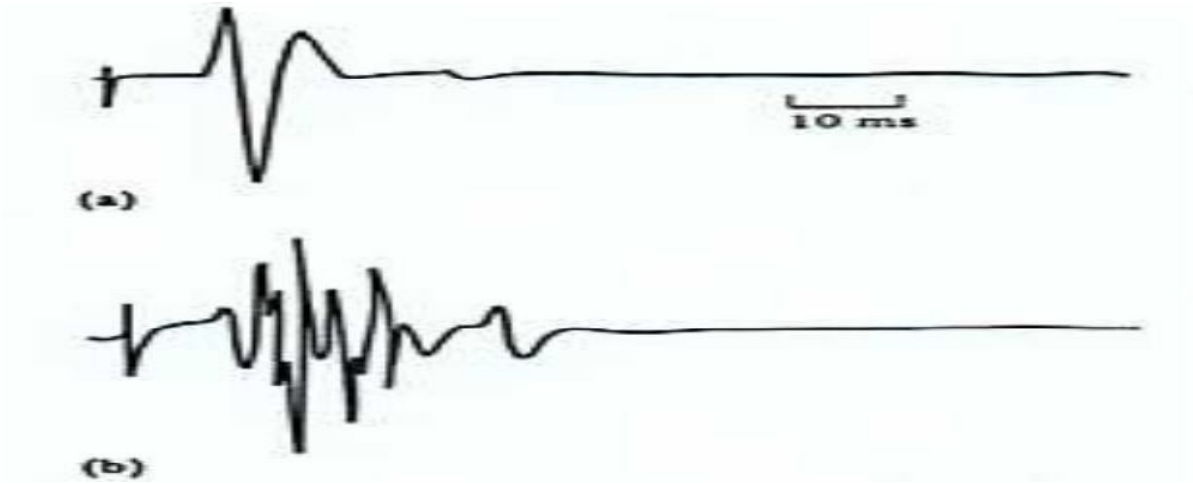


Fig. 1.32 EMG response of a normal and an abnormal waveforms

Applications of EMG:

EMG is used in the field of:

- Electrophysiological testing.
- Clinical neurophysiology.
- Neurology.
- Psychiatry.

UNIT III SIGNAL CONDITIONING CIRCUITS

1. List and discuss about important characteristics of Bio amplifier

(A/M 2017,N/D2017,N/D2018)

Need for Bio amplifiers

7. Biological/bioelectric signals have low amplitude and low frequency.
8. Therefore, to increase the amplitude level of bio-signals amplifiers are designed.
9. The outputs from these amplifiers are used for further analysis and they appear as ECG, EMG, or any bioelectric waveforms.
10. Such amplifiers are defined as Bio Amplifiers or Biomedical Amplifiers.

Basic Requirements for Biological Amplifiers

- The biological amplifier should have a high input impedance value. The range of value lies between 2 MΩ and 10 MΩ depending on the applications. Higher impedance value reduces distortion of the signal.
- When electrodes pick up bio-potentials from the human body, the input circuit should be protected.
- Every bio-amplifier should consist of isolation and protection circuits, to prevent the patients from electrical shocks.
- Since the output of a bioelectric signal is in millivolts or microvolt range, the voltage gain value of the amplifier should be higher than 100dB.
- Throughout the entire bandwidth range, a constant gain should be maintained.
- A bio-amplifier should have small output impedance.
- A good bio-amplifier should be free from drift and noise.
- Common Mode Rejection Ratio (CMRR) value of amplifier should be greater than 80dB to reduce the interference from common mode signal.
- The gain of the bio-amplifier should be calibrated for each measurement.

Differential Amplifier

5. Differential Amplifier is a device which is used to amplify the difference between the voltages applied at its inputs. Such circuits can be of two types viz.,
6. Differential amplifiers built using transistors, either Bipolar Junction Transistors(BJTs) or Field Effect Transistors (FETs)
7. Differential amplifiers built using Op-Amps.
8. The above Figure shows such a circuit made of two BJTs (Q1 and Q2) and two power supplies of opposite polarity viz., VCC and –VEE which uses three resistors among

which two are the collector resistors, RC1 and RC2 (one for each transistor) while one is the emitter resistor RE common to both transistors.

9. Here the input signals (V1 and V2) are applied to the base of the transistors while the output is collected across their collector terminals (Vo1 and Vo2).

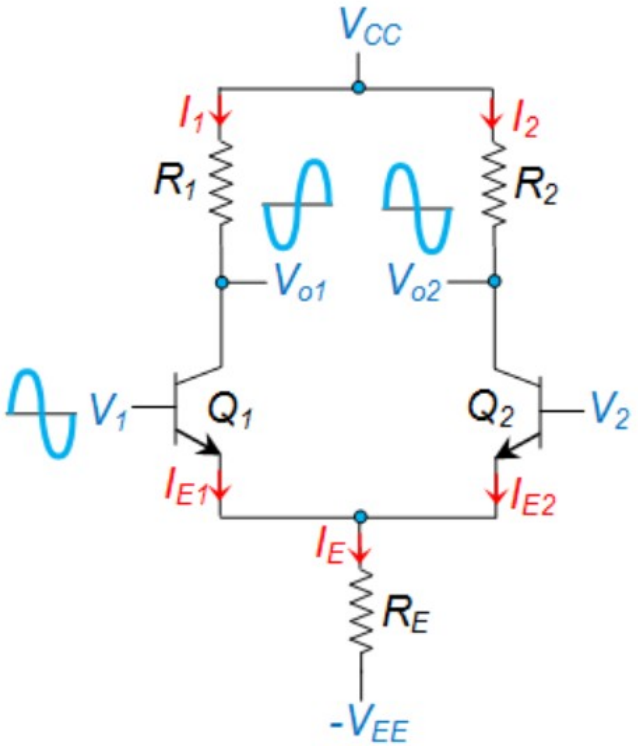


Fig 3.3 Differential amplifier

12. In this case, if the V1 at Q1 is sinusoidal, then as V1 goes on increasing, the transistor starts to conduct and this results in a heavy collector current IC1 increasing the voltage drop across RC1, causing a decrease in Vo1.

13. Due to the same effect, even IE1 increases which increases the common emitter current, IE resulting in an increase of voltage dropacross RE.

14. This means that the emitters of both transistors are driven towards positive which in-turn implies that the base of Q2 would start to become more and more negative.

15. This results in a decrease of collector current, IC2 which in-turn decreases the voltage drop across the collector resistor RC2, resulting in an increase in the output voltage Vo2.

16. This indicates that the changes in the sinusoidal signal observed at the input of transistor Q1is reflected as such across the collector terminal of Q2 and appear with a phase difference of 180o across the collector terminal of Q1.

17. The differential amplification can be driven by considering the output in-between the collector terminals of the transistors, Q1 and Q2.

18. On the other hand, an Op-Amp operating in differential mode can readily act as a differential amplifier **as** it results in an output voltage given by

$$V_0 = A_d(V_1 - V_2)$$

Where V1 and V2 represent the voltages applied at its inverting and non-inverting input terminals (can be taken in any order) and Ad refers to its differential gain.

19. As per this equation, the output of the OpAmp must be zero when the voltages applied at its terminals are equal to each other.

20. However practically it will not be so as the gain will not be same for both of the inputs.

21. Thus, in real scenario, the mathematical expression for the output of the differential amplifier can be given as

$$V_0 = A_d(V_1 - V_2) + A_C\left(\frac{V_1 + V_2}{2}\right)$$

Where AC is called the common mode gain of the amplifier.

22. Thus, functionally-good difference amplifiers are expected to exhibit a high common mode rejection ratio (CMRR) and high impedance.

23. However, it is to be noted that an Op-Amp can be suitably configured to result in a much practical differential amplifier, as shown by blow Figure.

24. If closely observed, one can note that this circuit is just a combination of inverting and non-inverting amplifier.

25. Hence its output voltage will be equal to the sum of the output voltages produced by the Op-Amp circuit operating as an inverting amplifier and the Op-Amp circuit Operating as a non-inverting amplifier.

Thus, one gets,

$$V_0 = -\frac{R_f}{R_1}V_1 + V_2\frac{R_f}{R_2 + R_3}\left(1 + \frac{R_f}{R_1}\right)$$

Now, if R1 = R2 and R3 = Rf, then

$$V_0 = -\frac{R_f}{R_1}V_1 + V_2\frac{R_f}{R_1 + R_f}\left(\frac{R_1 + R_f}{R_1}\right)$$

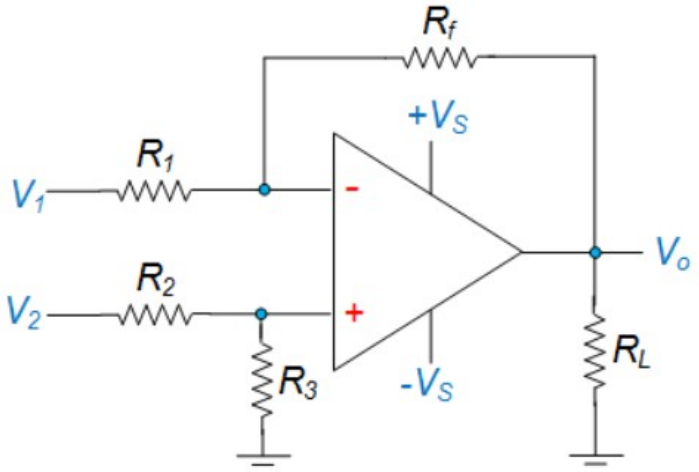


Fig 3.4 Differential amplifier

This implies that the gain of the **differential amplifier** circuit shown in above Figure is given by.

$$-\frac{R_f}{R_1}$$

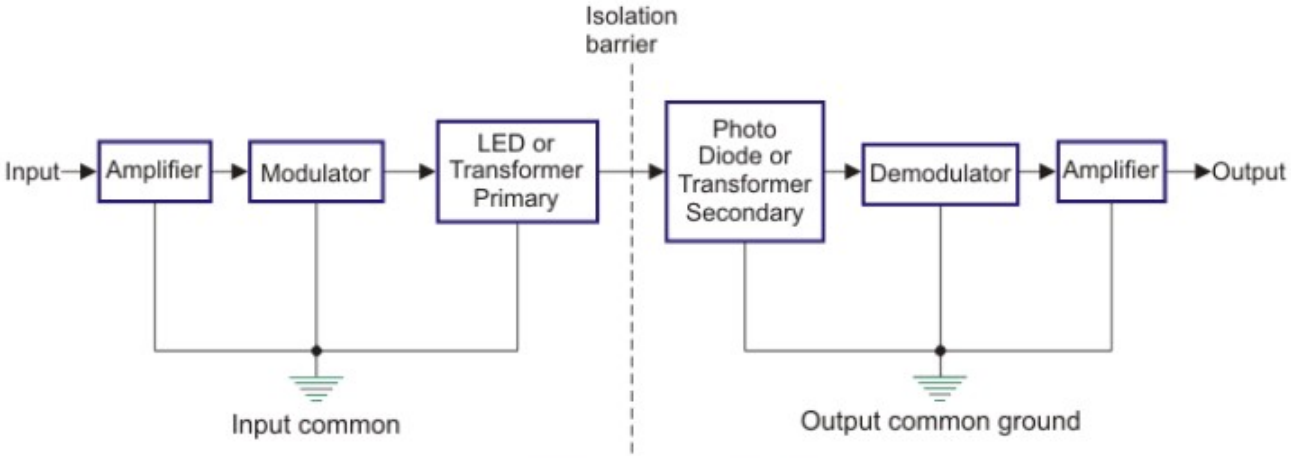
15. In addition, it is to be noted that the basic circuit shown by above Figure can be modified in many ways resulting in various circuit designs including Wheatstone bridge differential amplifier, light activated differential amplifier and instrumentation amplifier.

16. These devices are used as motor and/or servo controllers, signal amplifiers, analog multipliers, switches, volume controllers, automatic gain controllers, amplitude modulators, etc. and cover a wide range of applications including those in instrumentation systems, microphones, analog to digital converters applications.

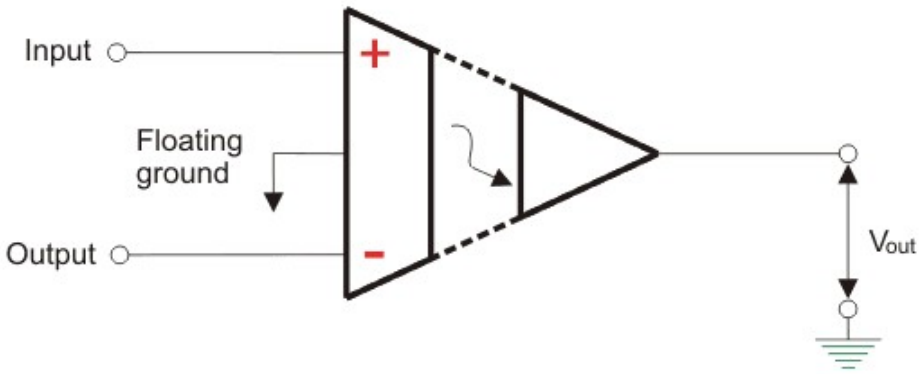
Isolation Amplifier

- Isolation amplifiers are known as Pre-amplifier isolation circuits.
- An isolation amplifier increases the input impedance of a patient monitoring system.
- It also helps to isolate the patient from the device.
- Using the isolation amplifier prevents accidental internal cardiac shock.
- It provides up to 1012 Ω insulation between the patient and the power line in the hospital.
- The electrical signals are obtained with electrodes. The signals received goes to the amplifier block, where signals amplification occurs.
- After amplification, the signal enters the modulation block. When either it goes to the isolation barrier, optical cable or transformer can be used.
- If in case of optical cable, modulator output travels to LED. The LED converts electrical signals into light energy.

- If the transformer acts an isolation barrier, modulator output connects the primary winding of the transformer.
- Energy from primary transfers to the secondary winding based on the mutual induction principle.
- At the next stage, secondary output enters the demodulation block. Finally, the amplified demodulated signal is obtained.



Block Diagram of Isolation Amplifier



Symbol of Isolation Amplifier

Fig 3.1 Isolation Amplifier

ECG Isolation Amplifier

- During ECG measurement, signals generated from all leads are sent to the low pass filter. This filter is named as Electro surgery filters because it decreases the interference between electro-surgery and radio frequency.
- Next block is the high voltage and overvoltage protection that can withstand large voltage during defibrillation.

- Proceeding further, it goes to Lead Selector Switch block, which selects the required configuration.
- Lead selection output goes to the DC amplifier. We have a transformer, whose primary winding is connected to the oscillator and secondary to rectifier and filter.
- ECG signal is modulated with the Synchronous modulator.
- The second transformer delivers the output from the synchronous modulator to the synchronous demodulator.
- The output from the demodulator is fed as input to the power amplifier.

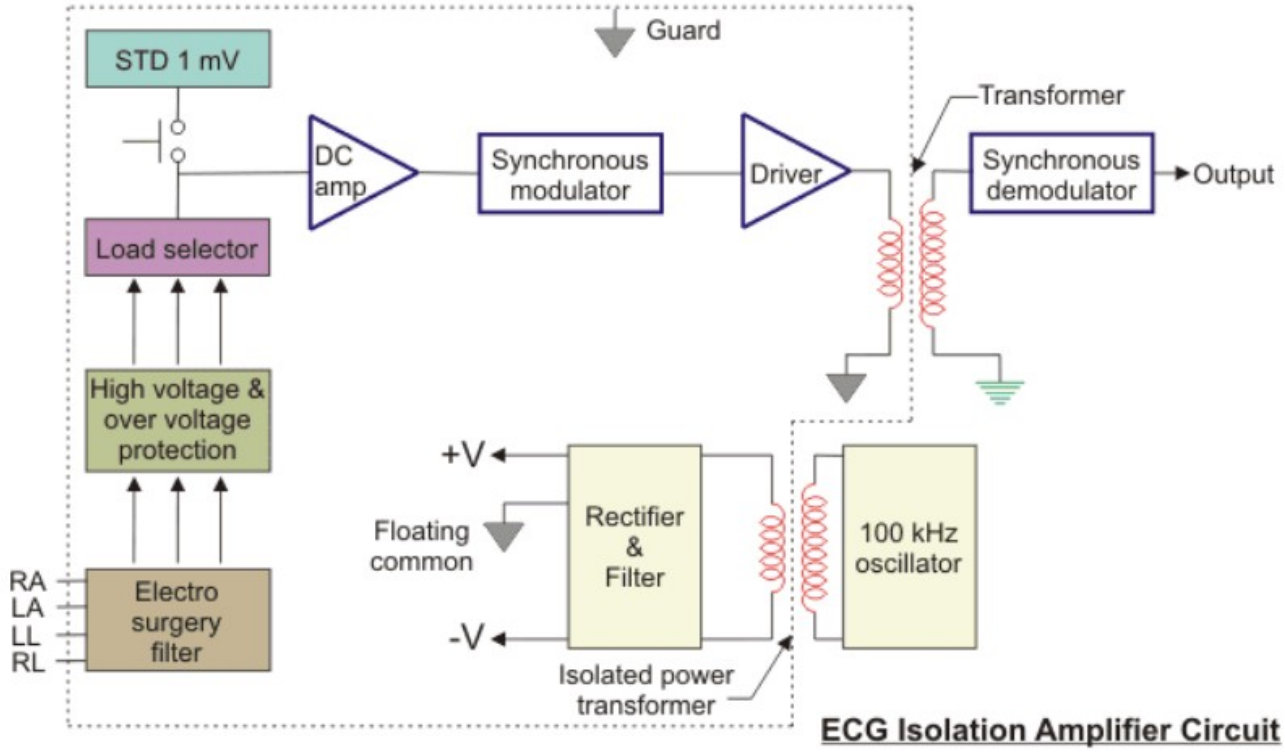


Fig 3.2 ECG isolation Amplifier circuit

UNIT IV MEASUREMENT OF NON-ELECTRICALPARAMETERS

1.Respiratory measurement

They are used to evaluate the state of lungs or respiratory process. The three basic types of measurement are ventilation, distribution and diffusion.

Ventilation:

- Ventilation deals with the determination of the ability of body to displace air volume quantitatively and the speed with which it moves the air.
- Spirometers are used in the ventilation measurement.

Distribution:

- It indicates the degree of lung obstructions for the flow of air and also determines the residual volume of air that cannot be removed from the lungs.
- Pneumatachomaters are used measure the instantaneous rate of volume flow of respired gases.

Diffusion:

- It indicates the lung ability to exchange gas with the circulatory system or the rate at which gas is exchanged with the blood stream.

Lung volumes and capacities

- Pulmonary function analyzers are used to determine the lung volumes and capacities. These parameters depend on individual's physical characteristics and condition of breathing mechanism.
- Lung capacities are indicated by milliliters and lung volumes are indicated by percentages.

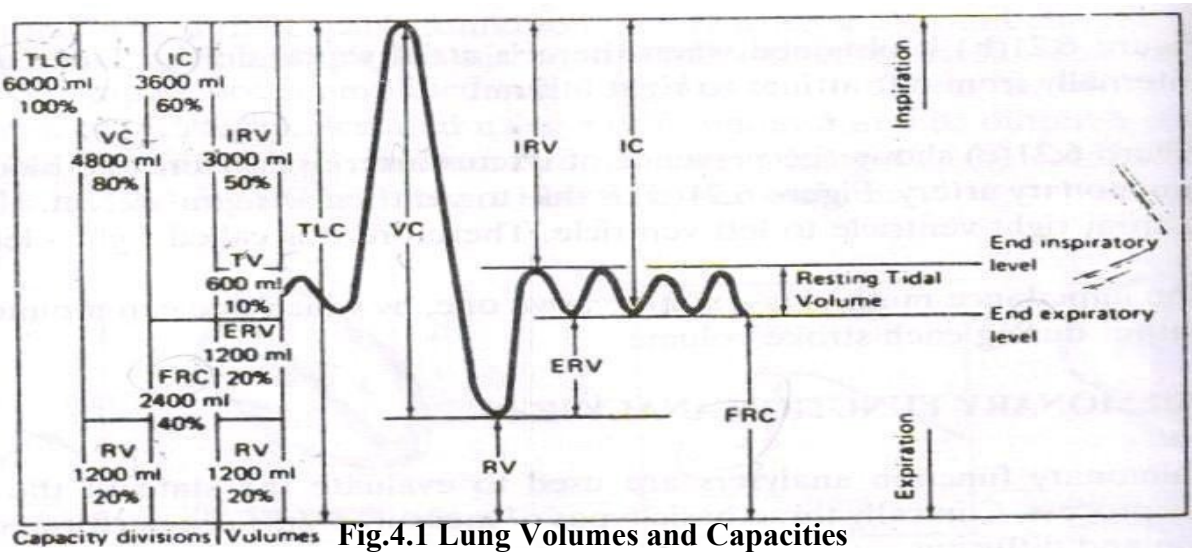


Fig.4.1 Lung Volumes and Capacities

Abbreviation	Full form	Definition
TLC	Total lung capacity	It is the total amount of gas contained in the lungs at the end of a maximal inspiration. It is the sum of vital capacity and residual volume.
VC	Vital capacity	Maximum volume of gas that can be expelled from the lungs after the maximal inspiration.
TV	Tidal volume	It is the volume of gas inspired or expired during each normal, quiet and respiration cycle.
RV	Residual volume	It is the volume of gas remaining in the lung at the end of a maximal expiration.
IRV	Inspiratory reverse volume	Extra volume of gas that can be inspired with maximal effort after reaching the normal end of inspiratory level.
ERV	Expiratory reverse volume	It is the extra volume of gas that can be expired with maximum effort beyond reaching the normal end of expiratory level.
IC	Inspiratory Capacity	It is the maximum amount of gas that can be inspired after reaching the end expiratory level.
FRC	Functional Residual Capacity	It is the volume of gas remaining in the lung at the end of expiratory level.
FVC	Forced vital capacity	It is the total amount of air that can forcibly be expired as quickly as possible after taking the deepest possible breath.
FEV	Forced Expiratory Volume	It is the maximum amount of gas that can be expelled at the given time.

2. Explain the different techniques used in measurement of pulse rate(A/M2018)

PULSE MEASUREMENT

10. When heart muscle contracts, blood are ejected from the ventricles and a pulse of pressure is transmitted through the circulatory system. This pulse can be measured at various points.

11. We can sense the pulse by placing our fingertip over the radial artery in the wrist. This pulse travels at the speed of 5 to 15m per second.

12. Photoelectric method is commonly employed to measure the pulse.

Types:

Photoelectric method consists of two types

26. Tramsmittance method

27. Reflectance method

TRANSMITTANCE METHOD OF PULSE MEASUREMENT

- LED and photo resistor are used in this method. These are mounted in a enclosure that fits over the tip of the finger.
- Light is produced by the LED. The same light is passed through the finger. For each heart pulse, blood is forced to the extremities and the amount of blood in the finger is increased.

- So optical density is changed. So, the light transmitted through the finger is decreased. This light is received by the photo resistor.
- This photo resistor is connected with the part of voltage divider circuit. The voltage produced by this circuit is directly proportional to the amount of blood flow in the figure.
- The output is recorded by using strip chart recorder.

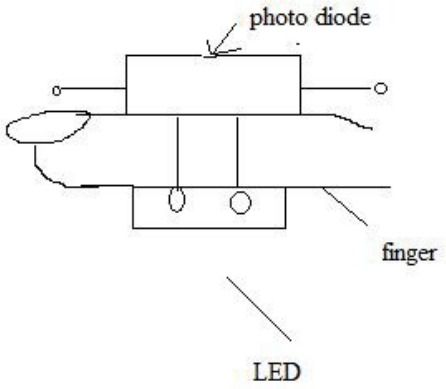


Fig.4.2 Transmittance Method Of Pulse Measurement

REFLECTANCE METHOD

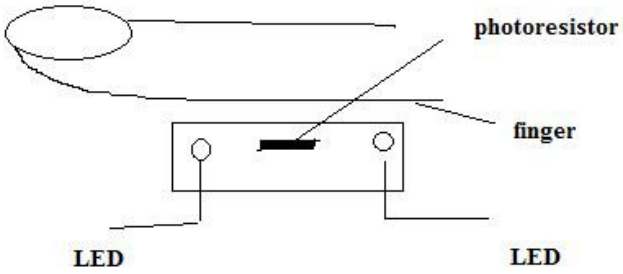


Fig.4.3 Reflectance Method

N reflectance method, LED is placed adjacent to the photo resistor. LED emits the light. This light is reflected form the skin and the tissues falls on the photo resistor. The reflected light varies depending upon the blood flow in the finger. The photo resistor is connected as a part of the voltage divider circuit. The output obtained is directly proportional to the amount of blood in the finger. The output can be recorder using strip chart recorder.

3. Blood pressure

The pressure of the blood in the circulatory system, often measured for diagnosis since it is closely related to the force and rate of the heart beat and the diameter and elasticity of the arterial walls.Pressure is defined as force per unit area,

P = F / A P = pressure in pascal,

F=Force,

A=Area

Thus pressure is increased by increasing the applied force or by decreasing the area.

Systolic blood pressure

When our heart beats, it contracts and pushes blood through the arteries to the rest of our body. This force creates pressure on the arteries. This is called systolic blood pressure. A normal systolic blood pressure is 120 or below.

Diastolic blood pressure

The diastolic pressure is specifically the minimum arterial pressure during relaxation and dilatation of the ventricles of the heart when the ventricles fill with blood. In a blood pressure reading, the diastolic pressure is typically the second number recorded.

Methods

1. Indirect method using sphygmomanometer
2. Direct method

Indirect Method using Sphygmomanometer:

- In this method Sphygmomanometer is used to measure blood pressure indirectly.
- It consists of inflatable rubber bladder which is known as cuff, rubber squeeze ball pump & Valve assembly.
- Pressure is measured using manometer with mercury column.

Procedure to use Sphygmomanometer:

- Cuff is wrapped around the patient‘s upper arm at a point midway between elbow & Shoulder.
- Stethoscope is placed over the brachial artery at the distal border, because at this place, brachial artery comes close to surface.
- Initially the pressure in the cuff is raised well above the systolic pressure so that the flow of blood is completely terminated.
- Then pressure in the cuff is released at a particular rate.
- When the pressure reaches below the systolic pressure a brief flow of blood occurs.
- If the cuff pressure falls further below the diastolic pressure the flow of blood becomes normal and uninterrupted.
- At an exact instant the artery just opens and when it is fully opened it

makes a Korotkoff sound

- This Korotkoff sound appears when the cuff pressure falls just below the systolic pressure.
- The sound disappears just below diastolic pressure.
- These sounds are picked up by a microphone placed over an artery distal to the cuff.

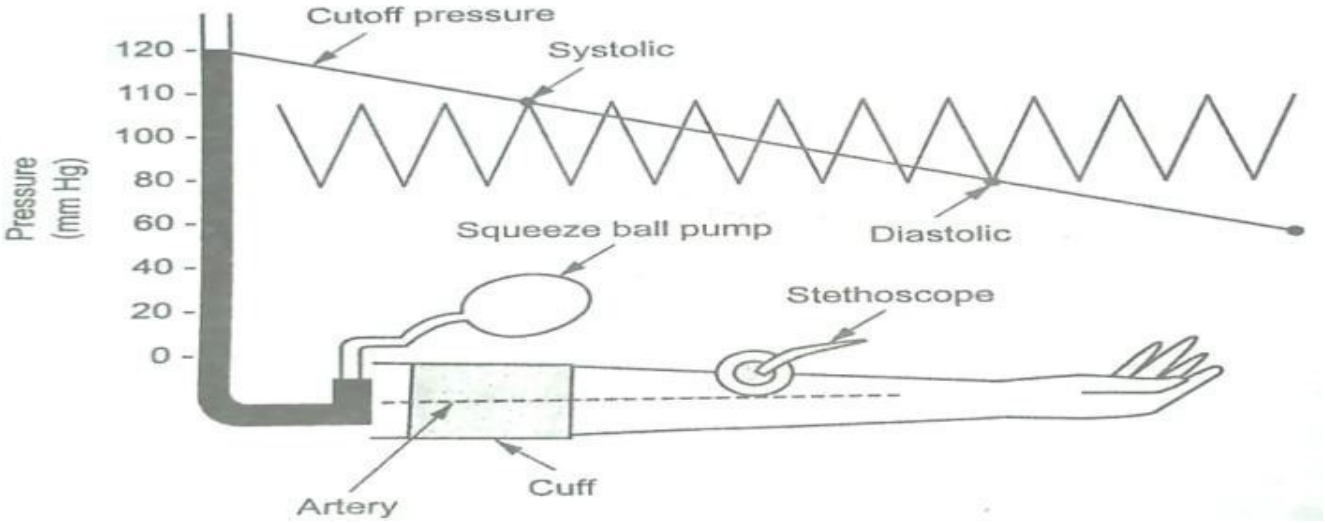


Fig.4.4 (a)Oscillometric or Ausculatory method

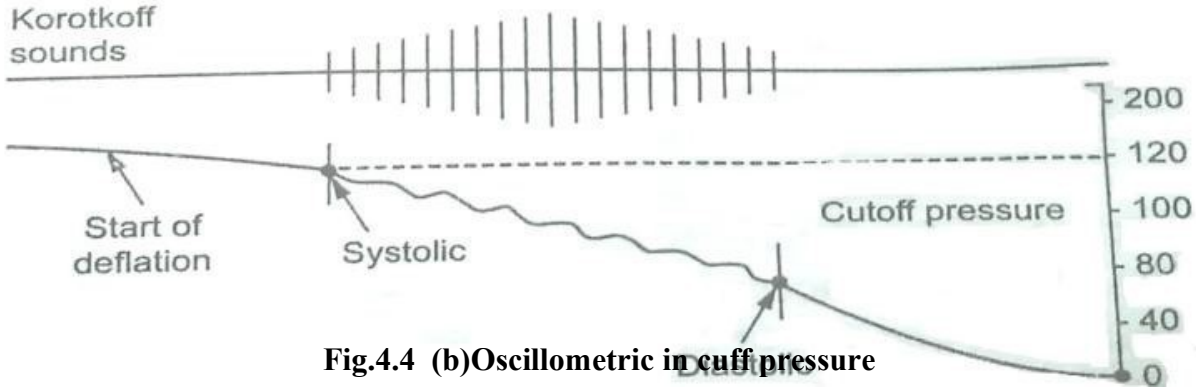


Fig.4.4 (b)Oscillometric in cuff pressure

Indirect method using sphygmomanometer

Thus the doctor slowly reduces the pressure in the cuff & he watches the mercury column when the systolic pressure exceeds the cuff pressure. Then doctor can hear some crashing, snapping sound through stethoscope. This sound is known as korotkoff sound.

Advantages

- Method is very simple
- Painless techniques

- There is no hazardous surgical procedure involved.

Disadvantages

Effective result depend on the fact how accurately doctor read pressure values when koratkoff sound is heard.

Direct Method of Blood Pressure Measurement:

- Direct method of blood pressure is used when highest degree of absolute accuracy, dynamic response and continuous monitoring is required.
- It is used to know blood pressures in deep regions which is inaccessible by indirect method.
- A catheter or a needle type probe is inserted through the vein or artery to the area of interest.
- Two types of probes are commonly used.
- One type has Catheter tip with sensor mounted at the tip of the probe. Pressure exerted on the tip is converted to the corresponding electrical signal.
- The other type is the fluid filled catheter type. Pressure exerted on the fluid filled column is transmitted to external transducer. This transducer converts pressure in to electrical signal.

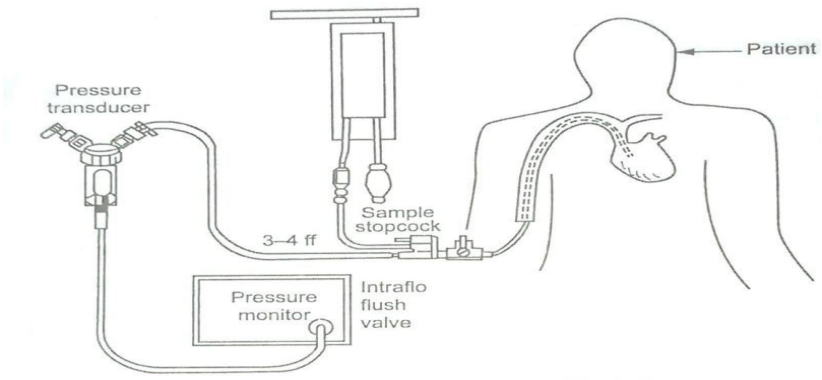


Fig.4.5 Direct blood pressure measurement

- A typical set up of a fluid filled system for measuring blood pressure is shown in Fig.4.5
- Here fluid filled catheter is used.
- Before inserting catheter into blood vessel, fluid filled system should be completely flushed out. Usually sterile saline is used for this purpose to avoid blood clotting in it.
- The system should be free from air bubbles.

Working:

Blood is taken from vessel using Cather tip probe. Pressure exerted is transmitted to the pressure transducer. The output of transducer is given to pressure monitor.

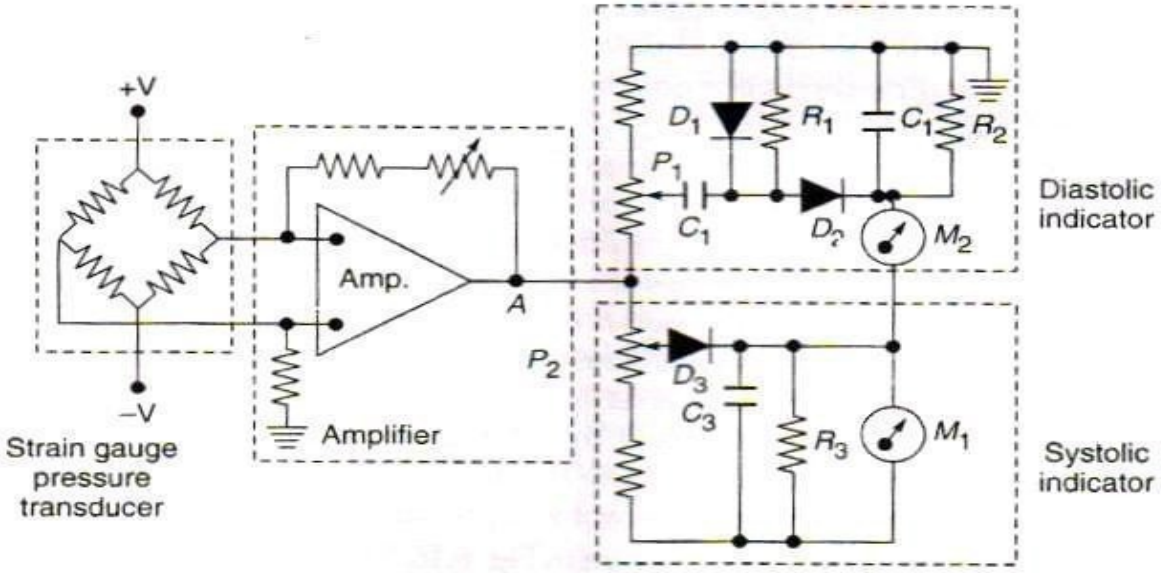


Fig.4.6 Circuit diagram for measurement of systolic and diastolic blood pressure

- Figure above shows a simplified circuit diagram commonly used for processing the electrical signals received from the pressure transducer for the measurement of arterial pressure.
- The transducer is excited with 5 V dc excitation.
- The electrical signal corresponding to the arterial pressure are amplified in an operational amplifier.
- For the measurement of systolic pressure, a conventional peak reading type voltmeter is used.
- The diastolic pressure is indicated by a second meter M2 in an indirect way.

  M2 reading = peak systolic value - peak to peak pressure value.

4.Explain the working principle of electromagnetic blood flow meter. What are its advantages and disadvantages? (May/June 2015)(May/June 2016) (May/June 2017)(Nov/ Dec2018)

BLOOD FLOWMETER

Blood flow meters are used to monitor the blood flow in various blood vessels and to measure cardiac output.

Types

- Electromagnetic blood flow meters
- Ultrasonic blood flow meters
- Laser based blood flow meters

ELECTROMAGNETIC FLOWMETERS

- Electromagnetic blood flow meters measure blood flow in blood vessels
- Consists of a probe connected to a flow sensor box

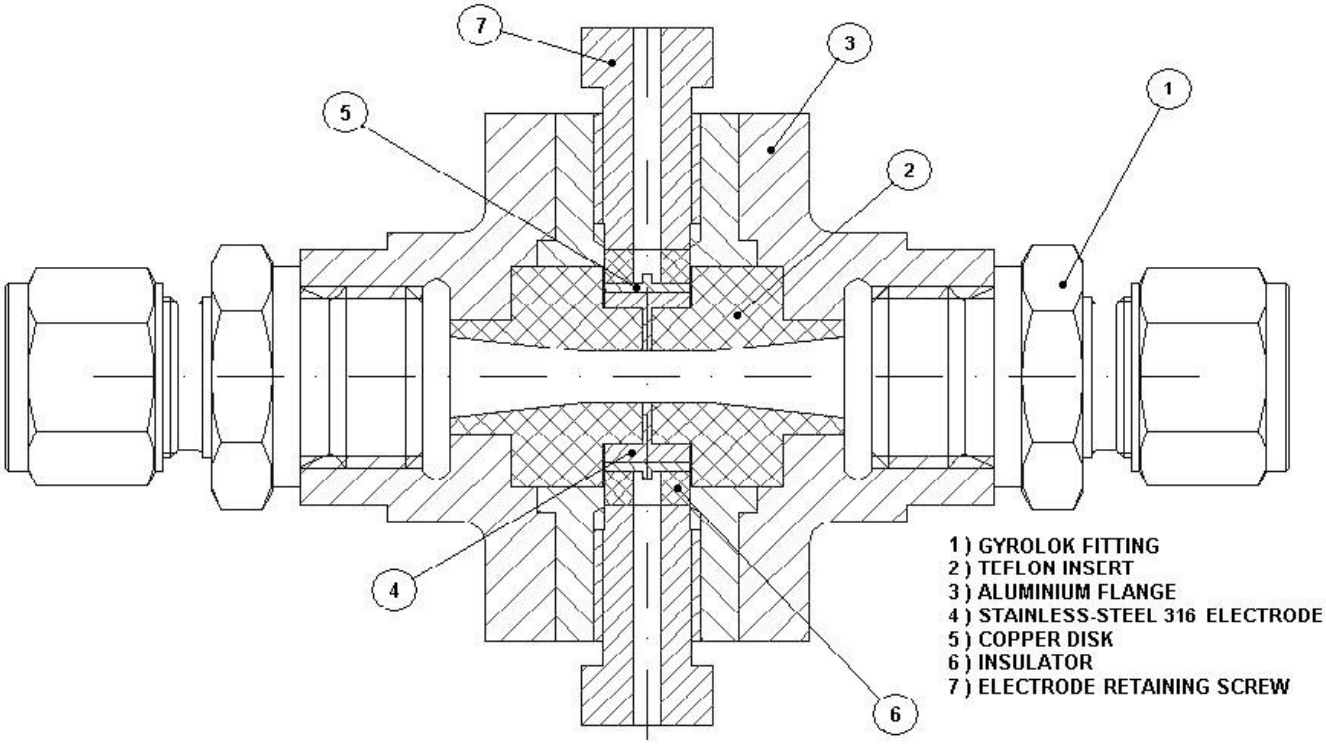


Fig.4.8 Electromagnetic flow meter

An Electromagnetic Flow Meter is a device capable of measuring the mass flow of a fluid. Unlike the common flow meter you can find on the market it has no moving parts, and for this reason it can be made to withstand any pressure (without leakage)and any fluid(corrosive and non corrosive). This kind of flow meter use a magnet and two electrodes to peek the voltage that appears across the fluid moving in the magnetic field.

The Neumann Law (or Lenz Law) states that if a conductive wire is moving at right angle through a magnetic field, a voltage ***E*** [Volts] will appear at the end of the conductor

E=B*L*V

Where

B = Magnetic Induction

[Weber/m2]

L = Length of the portion of the wire 'wetted' by the magnetic field [m]

V = Velocity of the wire [m/sec]

Fig.2

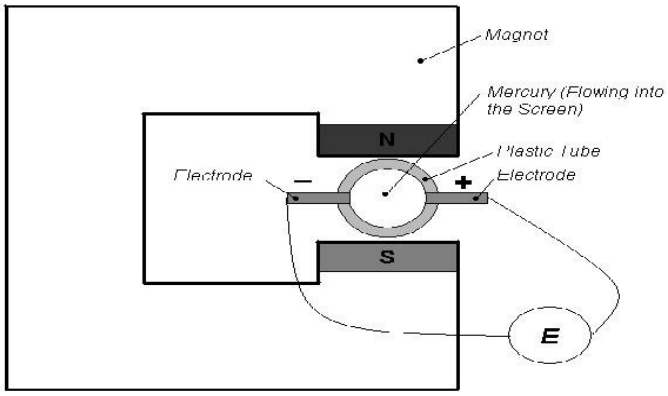


Fig.4.9 Magnetic Blood flow meter principle

Now imagine you have a plastic tube with two electrodes on the diameter and Mercury flowing into it. A voltage will appear on the electrodes and it will be

E=B*L*V

As in the previous example (***L*** in this case is the inner diameter of the tube).Mercury as tiny conductive wires next to each other: each wire, moving in the tube, will touch the two elec-trodes, and thus you can measure their voltage.

An interesting fact is that if you reverse the flow, you still get a voltage but with reverse polarity (Fig.1). Till now we have talked about a conductive fluid ,Mercury, but this stuff will also work with non-conductive fluid, provided that you use an alternating magnetic field. Two physicists, Middleman and Cushing, in an unpublished work, stated that when using a non-conductive fluid, if the frequency of the alternating magnetic field is ***v*** the voltage at the electrodes will be attenuated by a factor ***a*** so that:

Measuring the flow

A perfect axisymmetric construction cannot be achieved and thus some magnetic flux lines will 'wet' the connecting wires to the electrodes. The alternating magnetic field will create an offset voltage in this wire and even if the fluid is not moving, the measured voltage will not be zero.

ULTRASONIC FLOWMETERS

The blood cells in the fluid scatter the Doppler signal diffusively. In the recent years ultrasound contrast agents have been used in order to increase the echoes. The ultrasound beam is focused by a suitable transducer geometry and a lens.

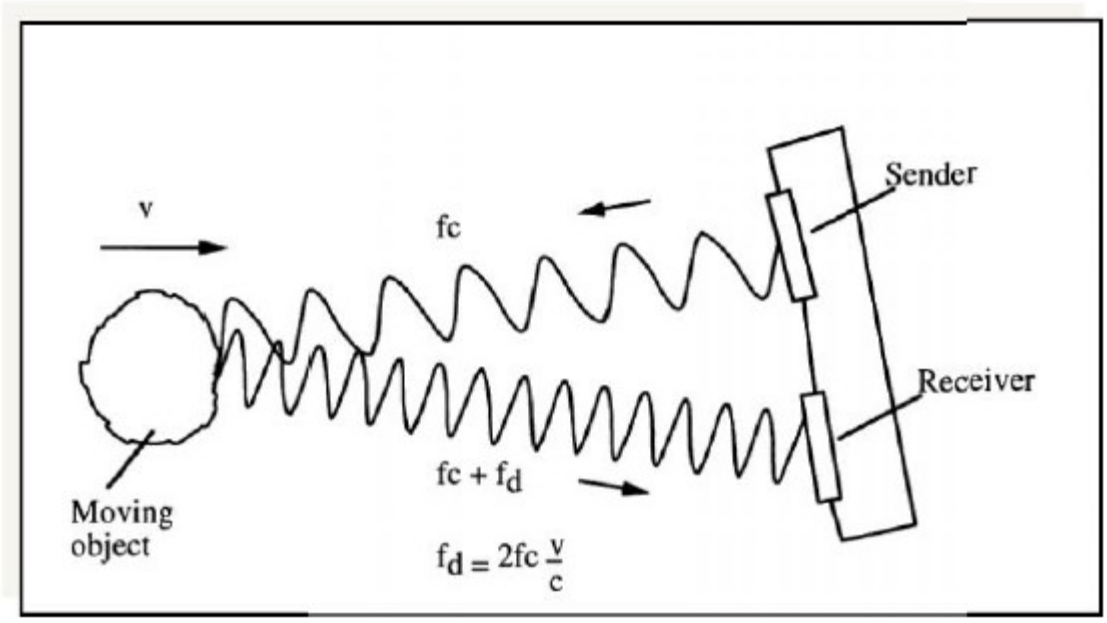


Fig.4.10 Ultrasonic flow meter

fd = 2fcv/c
f = 2- 10 MHz
c = 1500 - 1600 m/s (1540 m/s)
f = 1,3 – 13 kHz

In order to know where along the beam the blood flow data is collected, a pulsed Doppler must be used. The flow velocity is obtained from the spectral estimation of the received Doppler signal. The ultrasound Doppler device can be either *a continuous* wave or a pulsed Doppler.

A Continuous Wave

- No minimum range
- Simpler hardware
- Range ambiguity
- Low flow cannot be detected

A Pulsed Doppler

11. Accuracy
12. No minimum flow
13. Minimum range

(Maximum flow) x (range)= limited the power decays exponentially because of the heating of the tissue. The absorption coefficient ~ proportional to frequency the far field operation should be avoided due to beam divergence.

Dnf = D2/ 4

D = Transducer diameter (e.g. 1 – 5 mm) the backscattered power is proportional to *f* .The resolution and SNR are related to the pulse duration. Improving either one of the parameters always affects inversely to the other.

LASER DOPPLER FLOWMETRY

The principle of measurement is the same as with ultrasound Doppler. The laser parameter may have the following properties:5 mWHe-Ne-laser 632,8 nm wavelength.

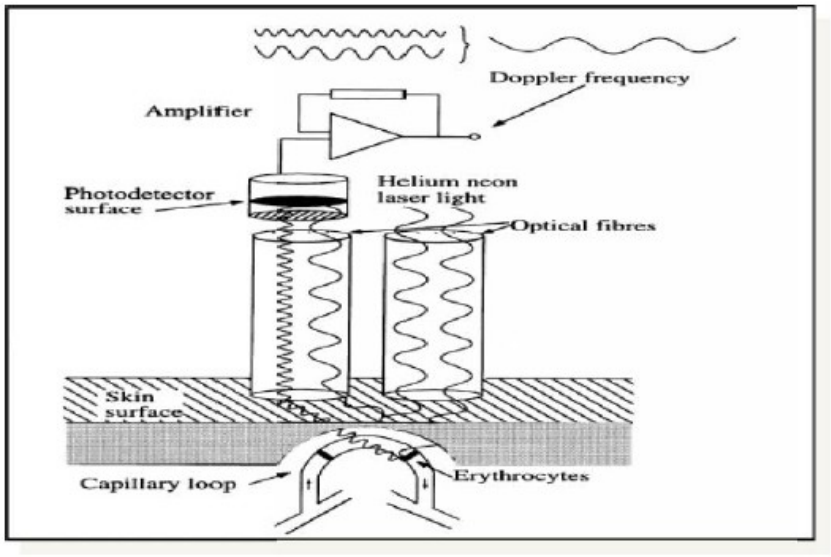


Fig.4.11 Laser Doppler flow meter

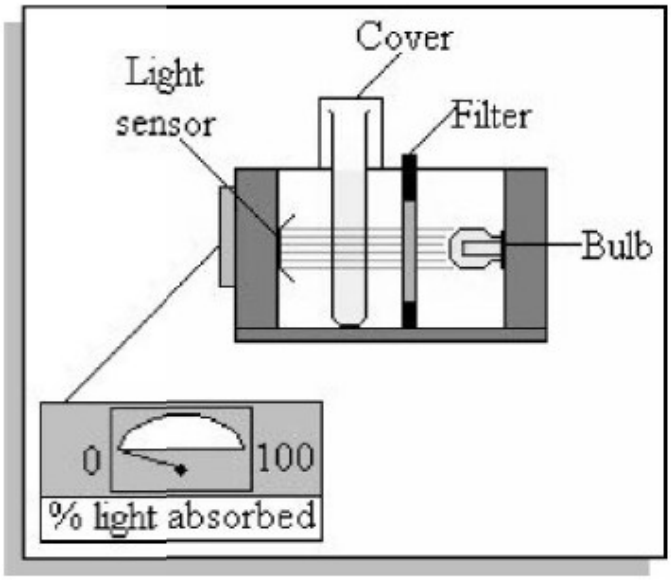
The moving red blood cells cause Doppler frequency 30 – 12 000 Hz. The method is used for capillary (microvascular) blood flow measurements

5.Define the term "Cardiac Output". How is cardiac output measured by dye dilution technique? Explain. (May/June 2017)(Nov/Dec 2018)

Indicator Dilution Methods

Dye Dilution Method

A bolus of indicator, a colored dye *(indocyanine green),* is rapidly injected in to the vessel. The concentration is measured in the downstream The blood is drawn through a colorimetric cuvette and the concentration is measured using the principle of absorption photometry.



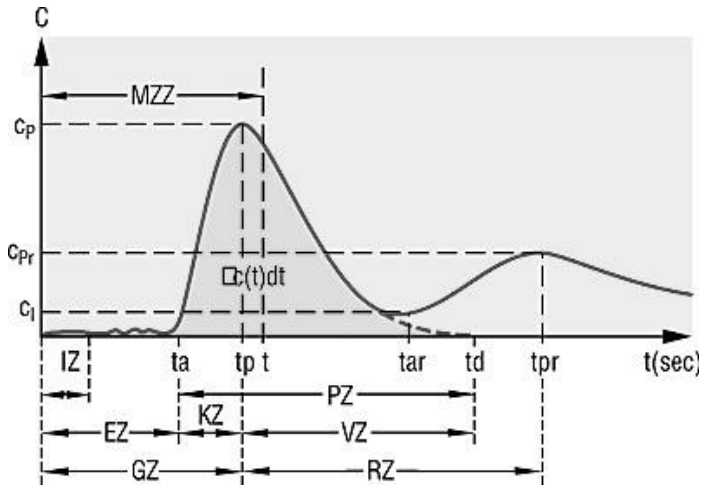


Fig.4.12 Dye Dilution method

Thermal Dilution Method

A bolus of chilled saline solution is injected into the blood circulation system (right atrium). This causes decrease in the pulmonary artery temperature. An artery puncture is not needed in this technique .Several measurements can be done in relatively short time .A standard technique for measuring cardiac output in critically ill patients.

CARDIAC OUTPUT

- It is the amount of blood delivered by th heart to the aorta per minute.
- In the case of adult the amount of blood pumped ranges from 70 to 100ml in each beat. Hence for normal adult the cardiac output is about 4- 6 liters / min.
- Decrease in cardiac output is due to low blood pressure, reduced tissue oxygenation, poor renal function, shock and acidosis.

Two methods are available

(i) Direct method (ii) In direct method electromagnetic flow probe

is implanted on the aorta by surgery. It is the product of stroke volume and heart

beat rate per minute)

(ii) Indirect method

Flick's Method:

- This is based on the determination of cardiac output by the analysis of gas-keeping of the organism.
- It is calculated by continuously infusing oxygen into the blood or removing it from the blood and measuring the amount of oxygen in the blood before and after its passage.
- I = CAQ - CVQ

  I– amount of infused or removed oxygen per unit time.

  CA, CV – Concentration of oxygen in atrial blood (outgoing) and mixed venous blood (incoming blood) respectively. Q – Cardiac output. Therefore, Q=I/(CA-CV)
- The oxygen consumption is determined by analyzing the exhaled air collected in a bag during 10 min.
- CV is measured by taking samples from a central vein through a cardiac catheter.
- CA is analyzed by taking samples from artery in fore arm.

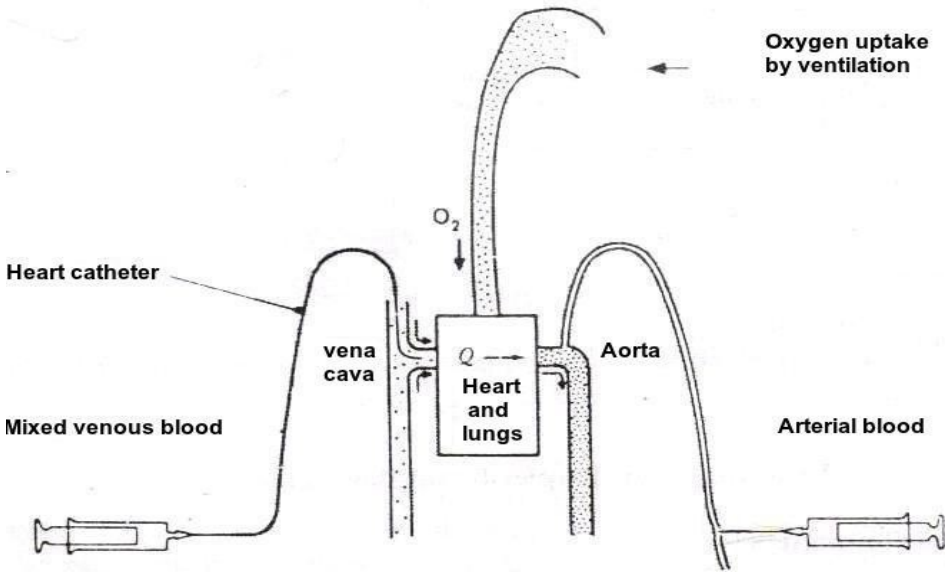


Fig.4.16 Flick's method

Indicator Dilution Method:

- This is based on the principle that if we introduce an indicator (dye or radioisotope) in the blood circulation and then measuring the concentration of indicator with respect to time, we can estimate the volume flow of blood.
- Let M mg of an indicator is injected into the right heart.

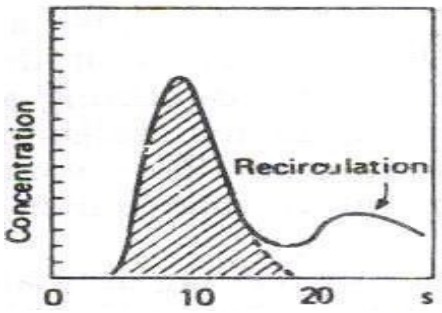


Fig.4.17 Dilution curve

- During the first circulation period, the indicator would mix up with the blood in a small quantity.
- After that there is a rapid change of concentration. This is shows by rising portion of dilution curve. After reaching maximum, the concentration of indicator decreased exponentially.
- When the indicator is completely mixed up with the blood the curve becomes parallel with the time axis.

  Cardiac output, Q= M/ Area of the curve
- Indicator dilution is more useful when there is no severe heart defect. Here the diagnostic information can be obtained from the changes in the shape of dilution curve.

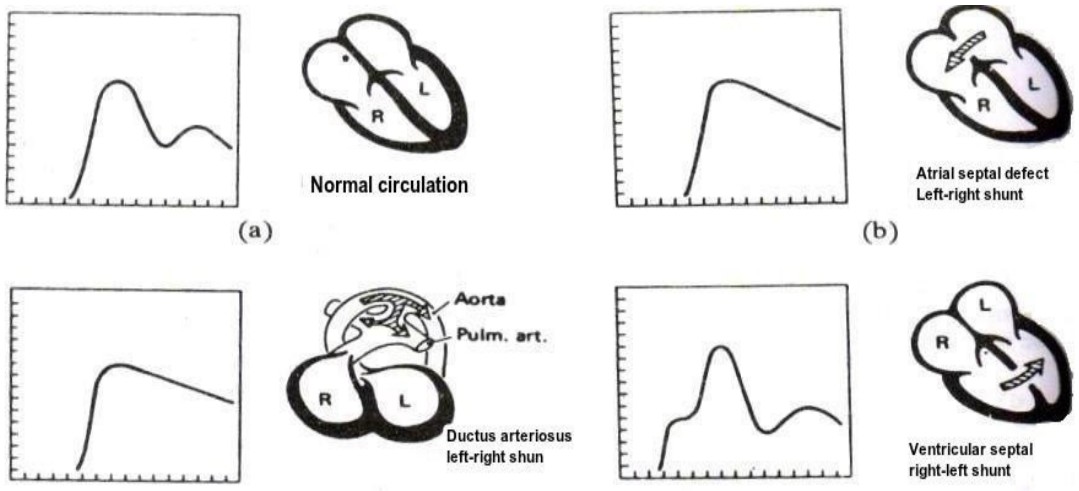


Fig.4.18 Dye dilution curves during presence of shunts

Fig. (a) shows the normal curve corresponding to the normal circulation of blood

Fig (b) shows atrial septal defect where blood flows internally from left atrium to right atrium.

Fig (c) shows ductus arterisous. Here blood flows from aorta to pulmonary artery.

Fig. (d) is due to ventricular septal defect (right left shunt). Here blood is flowing from right ventricle to left ventricle.

Disadvantages

- Foreign substances may be injected into the blood when the blood is taken for analysis.

Thermo Dilution Method

- Now-a-days thermo dilution method is adapted to measure cardiac output.
- A large pill of about 10 mL of 5 % Dextrose in water at room temperature is injected as a thermal indicator in right atrium.

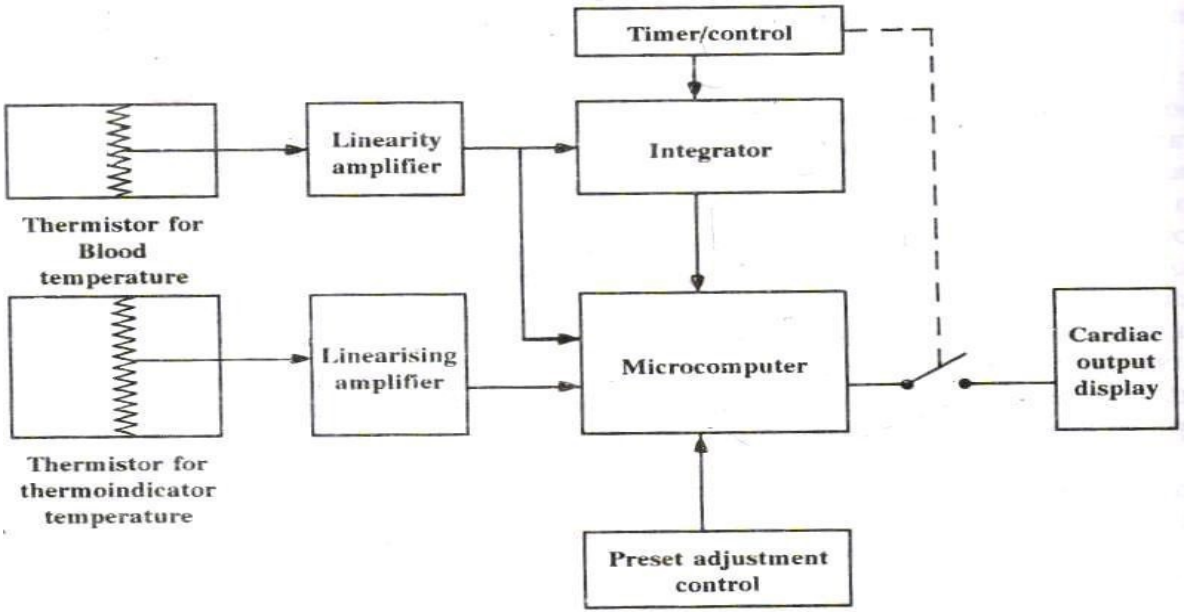


Fig. 4.19 Block diagram of thermo dilution system

After mixing, it is detected in the pulmonary artery by a catheter probe.

- The temperature difference between the injected temperature and the circulating blood temperature in the pulmonary artery is measured.
- After proper correction the meter reads the cardiac output.
- A linear relation between temperature and resistance of the thermistor can be maintained by connecting a parallel resistor with it.
- Based on this fact the linearizing amplifier works.
- Integrator delivers the value of integral of blood temperature change over a given time.
- By feeding data about the density and specific heat of blood and thermal indicator and volume of thermal indicator injected can deliver the cardiac output in lit/ min.

Measurement of cardiac output by impedance change

- By the impedance method, the cardiac output can be determined electronically.
- 4 probes method is adopted here. The electrode pair 1 & 4 is used as current electrodes.
- The electrode pair 2 & 3 are used to pick up the voltage across the thorax
- The electrode pair 2 & 3 is used to pick up the voltage across the thorax.
- If ρ ----resistivity of the patients hematocrit (the ratio of the volume of red blood cells to the total volume of blood),

  A ---- area of cross section of the thorax,
  L----- separation between the potential electrode 2 and 3. The resistance of the thorax is given by,

$R = \rho L/A$

$= \rho L^2/AL$

$= \rho L^2/V$

or $V = \rho L^2/R$

V---Volume of the thorax.

$dV = -\rho (L^2/R^2) dR$

By determining dV the cardiac output can be measured by multiplying dV with heart beat rate per minute.

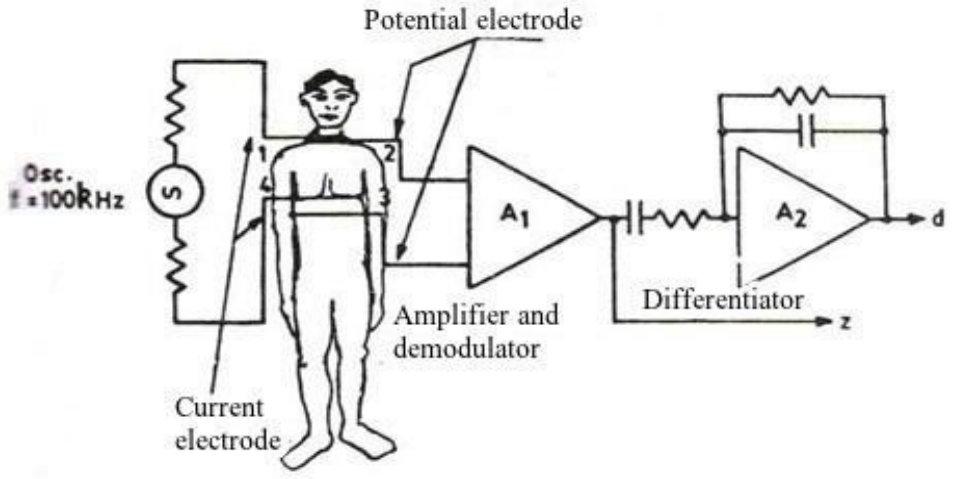


Fig.4.20 Measurement of Cardiac Output by Impedance Change

Advantages

- The impedance method is a noninvasive one (involving the introduction of instruments or other objects into the body or body cavities), by which one can monitor the cardiac output during each stroke volume.

[Stroke volume (SV) is the amount of blood pumped out of the heart during each contraction measured in mL/beat (milliliters per beat)]

UNIT V BIO-CHEMICAL MEASUREMENT

1.Explain the principle of following: pH measurement (May/June 2016) (May/June 2018) and auto analyzer (May/June 2011) (Nov/Dec 2017)

pH Measurement:

The chemical balance in the body can be determined by the ph value of blood and other body fluids.ph is defined as the hydrogen ion concentration of a fluid. It is the logarithm of the reciprocal value of h+ concentration. The ph equation is given as,

pH= - log10 [H+] = log10 1/[H+]

pH is the measure of acid- base balance in a fluid, A neutral solution has the ph value as 7. Solutions with pH value less than 7 are acidic and above 7 are basic. Most of the body fluids are slightly basic in nature.

Construction and working

The ph meter is made up of a thin glass membrane and it allows only the hydrogen ions to pass through it. The glass electrode provides a membrane interface for H+ ions. The glass bulb at the lower end of the ph meter contains a highly acidic buffer solution. The glass tube consists of a sliver-sliver chloride (Ag/Agcl) electrode and the reference electrode which is made up of calomel sliver-sliver chloride(Ag/Agcl) is tan placed in the solution in which ph is being measured.

The potential is measured across the two electrodes. The electrochemical measurement, which should be obtained by each of the electrodes called half- cell. The electrode potential is called as half-cell potential. Here the glass electrode inside the tube constitutes one half –cell and the calomel or reference electrode is considered as the other half-cell.

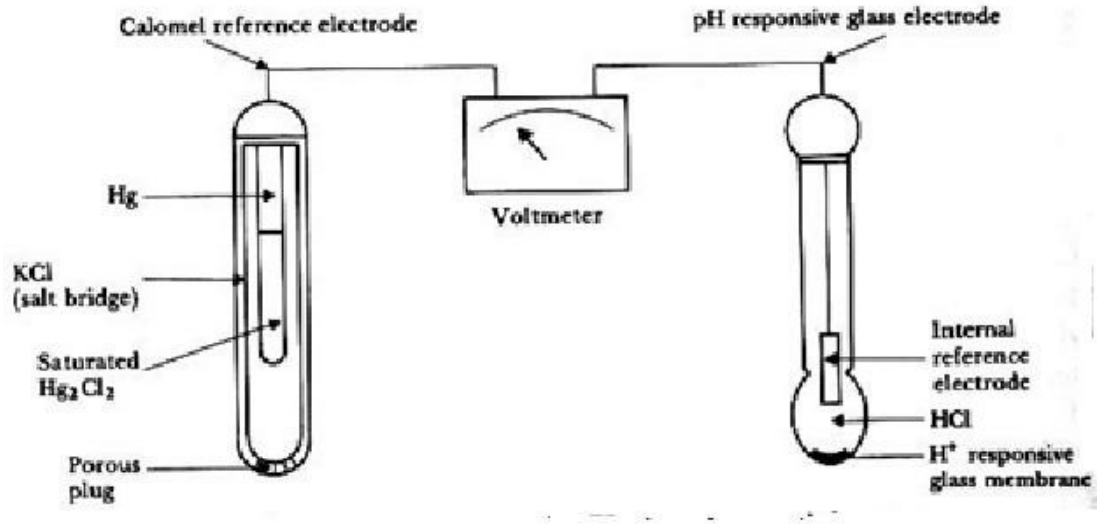


Fig.2.1 pH Electrode

For easier ph measurement combination electrodes are used. In this type both the active glass electrode and reference electrode are present in the same meter. The glass electrodes are suitable only to measure ph values around 7. Since this type of glass electrodes produce considerable errors during the measurement of high Ph values, special type of Ph electrodes are used. After every measurement the pH meter is washed with 20% ammonium biflouride

solution, for accurate results. The Ph meter with hydroscopic glass absorbs water readily and provides best pH value.

2.Describe the measurement of PO_2. (May/June 2017) (Nov/Dec 2017) (April/May2018)

pO2 MEASUREMENT

The term po2 is defined as the partial pressure of oxygen respectively. The determination of po2 is one the most important physiological chemical measurement. The effective functioning
of both respiratory and cardiovascular system can be by po2 measurement. The partial pressure of
a gas is proportional to the quantity of that gas present in the blood.
The platinum wire, which is an active electrode, is embedded in glass for insulation and only its tip is exposed. It is kept in the electrolyte solution in which the oxygen is allowed to diffuse. The reference electrode is made up of silver-silver chloride (Ab/AgCl). A voltage of 0.7 is applied between the platinum wire and the reference electrode. The negative terminal is connected to the active electrode through a micro ammeter and the positive terminal is given to the reference electrode.

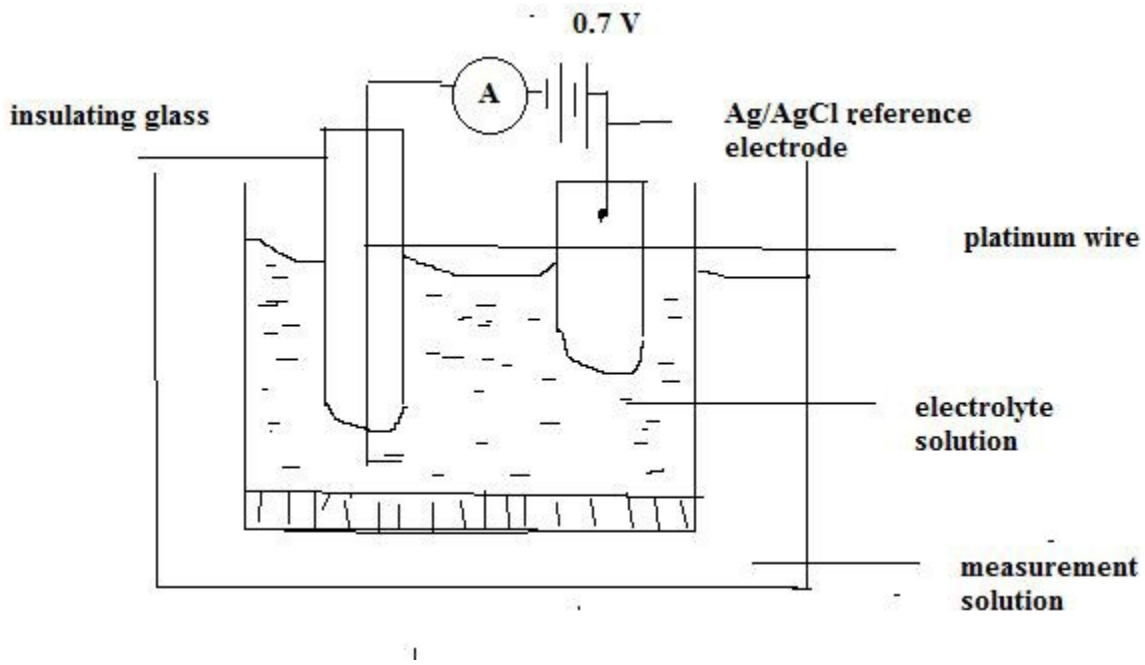


Fig.2.2 pO2 Electrode

Due to the negative terminal, the oxygen reduction takes place at the platinum cathode. Finally the oxidation reduction current proportional to the partial pressure of oxygen diffused into the electrolyte can be measured in the micro ammeter. The electrolyte is generally scaled in the electrode chamber by means of a membrane through which the oxygen can diffuse from the blood or sample solution.

There are two types of pO2 measurement. They are

I) Vitro measurement

II) Vivo measurement

In case of dark electrode the platinum cathode and the reference electrode is present in a single unit. This electrode is used for vitro and vivo measurements.

In Vitro Measurements

In this method the blood sample is taken and the measurement for oxygen saturation is made in the laboratory. The electrode is placed in the sample blood solution and the pO2 value is determined.

In Vivo Measurements

In this method the oxygen saturation is determined while the blood is flowing in the circulatory system. A micro version of the pO2 electrode is placed at the tip of the catheter so that it can be inserted into various parts of the heart or circulatory system.

The pO2 measurement also has some disadvantages in it. The reduction process in the platinum cathode removes a finite amount of the oxygen from the cathode. And there is a gradual reduction of current with respect to time. However careful design and proper procedures in modern pO2 electrodes reduce the errors.

pCO2 MEASUREMENT

The term pco2 is defined as the partial pressure of carbon dioxide respectively. The determination of pco2 is one the most important physiological chemical measurement. The effective functioning of both respiratory and cardiovascular system can be by pco2 measurement. The partial pressure of a gas is proportional to the quantity of that gas present in the blood.

The partial pressure of carbon dioxide can be measured with the help of pCO2 electrodes. Since there is a linear relationship between the logarithm of pCO2 and pH of a solution. The pCO2 measurement is made by surrounding a pH electrode with a membrane selectively permeable to CO2.

The modern improved pCO2 electrode is called as severinghous electrode. In this electrode the membrane permeable to CO2 is made up of Teflon which is not permeable to other ions which affects the pH value. The space between the Teflon and glass contains a matrix layer which allows only the CO2 gas molecules to diffuse through it.

One of the demerits in older CO2 electrode is, it requires a length of time for the CO2 molecules to diffuse through the membrane. The modern CO2 electrode is designed in such a way to overcome this demerit. Here the CO2 molecules diffuse rapidly through the membrane and the measurement can be done easily.

3.Explain the following: (i) Colorimeter (April/May2019) (ii) Auto analyzer (April/May2017)(Nov/Dec 2017)

COLORIMETER

🕐 Measures the color concentration of a substance in a solution by detecting the color light intensity passing through a sample containing the substance and a reagent

🕐 Optical color filters are used to detect the color wavelength of interest. E.g., urine passes yellow light and absorbs blue and green

🕐 Laser LEDs are preferred if their wavelength is suitable due to purity of the monochromatic color.

Fig2.3 Colorimeter

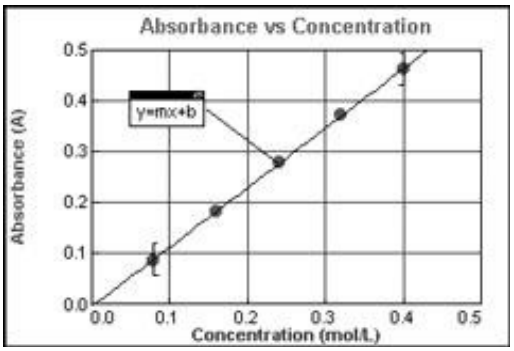


Fig.2.4 Concentration VS Absorbance

Transmittance

T= I1/I0 * 100%

Absorbance

A= - log I1/ I0

A=log 1/T

If the path length or concentration increases, the transmittance decreases and absorbance increases, a phenomenon expressed by Beer's Law.

Absorbtivity related to the nature of the $A=aCL$ absorbing substance and optical wavelength (known for a standard solutionconcentration).

C: Concentration

L: Cuvette path length

AUTOANALYZER

An auto analyzer sequentially measures blood chemistry through a series of steps of mixing,

reagent reaction and colorimetric measurements.

Itconsists of

- **Sampler:** Aspirates samples, standards, wash solutions into the system
- **Proportioning pump:** Mixes samples with the reagents so that proper chemical color reactions can take place, which are then read by the colorimeter
- **Dialyzer:** separates interfacing substances from the sample by permitting selective passage of sample components through a semi permeable membrane
- **Heating bath:** Controls temperature (typically at 37 °C), as temp is critical in color development
- **Colorimeter:** monitors the changes in optical density of the fluid stream flowing through a tubular flow cell. Color intensities proportional to the substance concentrations are converted to equivalent electrical voltages.

4.Write the principle of coulter counter with block diagram.Explain multi parameter coulter conyer(N/D2017)(A/M 2019)

BLOOD CELL COUNTER

• The blood cell counter counts the number of RBC or WBC per unit of volume of blood using either of two methods:

– Electrical method called aperture impedance change

– Optical method called flow cytometry

Aperture impedance change

• When blood is diluted in the proper type of solution, the electrical resistivity of blood cells (ρc) is higher than the resistivity of the surrounding fluid (ρf)

• By contriving a situation in which these resistivities can be differentiated from each other, we can count cells

Blood cell sensing

• The sensor consist of a two-chamber vessel in which the dilute incoming blood is on one side of barrier, and the waste blood to be discarded is on the other

• A hole with a small diameter (50μm) is placed in the partition between the two halves of the cell

• Ohmmeter measure the change on the resistance when the blood cell pass the aperture.

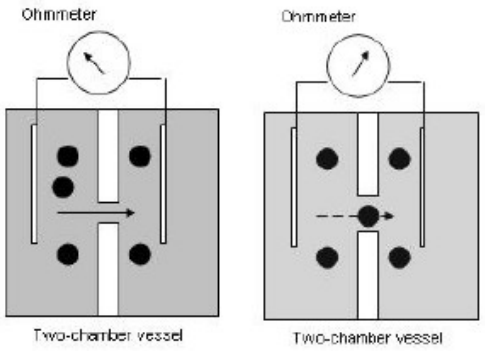


Fig.2.26 Blood cell sensing

COULTER COUNTER

• Constant current source (CCS) and voltage amplifier replace the ohmmeter

• RA is the resistance of the aperture and will be either high or low, depending on whether or not the blood cell is inside the aperture.

• Amplifier convert the current pulse to voltage pulse

UNIT III SIGNAL CONDITIONING CIRCUITS

1. List and discuss about important characteristics of Bio amplifier

(A/M 2017,N/D2017,N/D2018)

Need for Bio amplifiers

14. Biological/bioelectric signals have low amplitude and low frequency.
15. Therefore, to increase the amplitude level of bio-signals amplifiers are designed.
16. The outputs from these amplifiers are used for further analysis and they appear as ECG, EMG, or any bioelectric waveforms.
17. Such amplifiers are defined as Bio Amplifiers or Biomedical Amplifiers.

Basic Requirements for Biological Amplifiers

- The biological amplifier should have a high input impedance value. The range of value lies between 2 MΩ and 10 MΩ depending on the applications. Higher impedance value reduces distortion of the signal.
- When electrodes pick up bio-potentials from the human body, the input circuit should be protected.
- Every bio-amplifier should consist of isolation and protection circuits, to prevent the patients from electrical shocks.
- Since the output of a bioelectric signal is in millivolts or microvolt range, the voltage gain value of the amplifier should be higher than 100dB.
- Throughout the entire bandwidth range, a constant gain should be maintained.
- A bio-amplifier should have small output impedance.
- A good bio-amplifier should be free from drift and noise.
- Common Mode Rejection Ratio (CMRR) value of amplifier should be greater than 80dB to reduce the interference from common mode signal.
- The gain of the bio-amplifier should be calibrated for each measurement.

Differential Amplifier

13. Differential Amplifier is a device which is used to amplify the difference between the voltages applied at its inputs. Such circuits can be of two types viz.,

14. Differential amplifiers built using transistors, either Bipolar Junction Transistors(BJTs) or Field Effect Transistors (FETs)

15. Differential amplifiers built using Op-Amps.

16. The above Figure shows such a circuit made of two BJTs (Q1 and Q2) and two power supplies of opposite polarity viz., VCC and –VEE which uses three resistors among

which two are the collector resistors, RC1 and RC2 (one for each transistor) while one is the emitter resistor RE common to both transistors.

17. Here the input signals (V1 and V2) are applied to the base of the transistors while the output is collected across their collector terminals (Vo1 and Vo2).

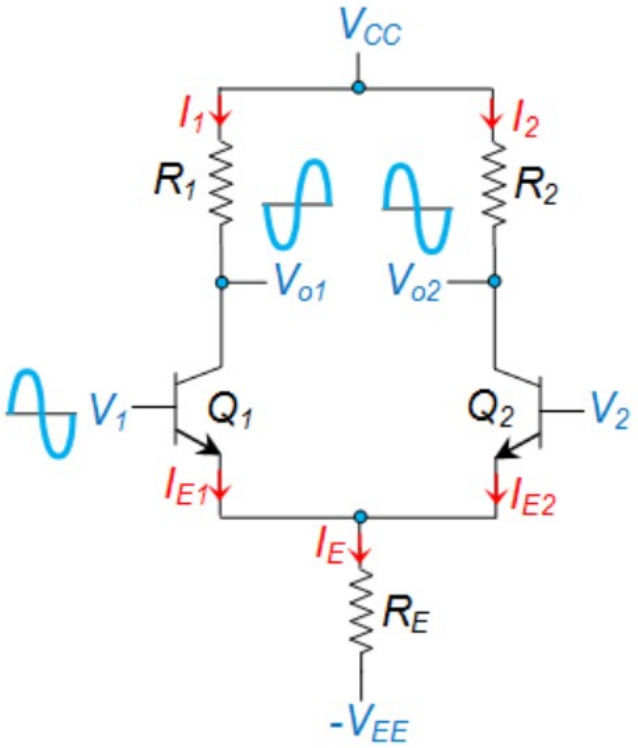


Fig 3.3 Differential amplifier

28. In this case, if the V1 at Q1 is sinusoidal, then as V1 goes on increasing, the transistor starts to conduct and this results in a heavy collector current IC1 increasing the voltage drop across RC1, causing a decrease in Vo1.

29. Due to the same effect, even IE1 increases which increases the common emitter current, IE resulting in an increase of voltage dropacross RE.

30. This means that the emitters of both transistors are driven towards positive which in-turn implies that the base of Q2 would start to become more and more negative.

31. This results in a decrease of collector current, IC2 which in-turn decreases the voltage drop across the collector resistor RC2, resulting in an increase in the output voltage Vo2.

32. This indicates that the changes in the sinusoidal signal observed at the input of transistor Q1is reflected as such across the collector terminal of Q2 and appear with a phase difference of 180o across the collector terminal of Q1.

33. The differential amplification can be driven by considering the output in-between the collector terminals of the transistors, Q1 and Q2.

34. On the other hand, an Op-Amp operating in differential mode can readily act as a differential amplifier **as** it results in an output voltage given by

$$V_0 = A_d(V_1 - V_2)$$

Where V1 and V2 represent the voltages applied at its inverting and non-inverting input terminals (can be taken in any order) and Ad refers to its differential gain.

35. As per this equation, the output of the OpAmp must be zero when the voltages applied at its terminals are equal to each other.

36. However practically it will not be so as the gain will not be same for both of the inputs.

37. Thus, in real scenario, the mathematical expression for the output of the differential amplifier can be given as

$$V_0 = A_d(V_1 - V_2) + A_C\left(\frac{V_1 + V_2}{2}\right)$$

Where AC is called the common mode gain of the amplifier.

38. Thus, functionally-good difference amplifiers are expected to exhibit a high common mode rejection ratio (CMRR) and high impedance.

39. However, it is to be noted that an Op-Amp can be suitably configured to result in a much practical differential amplifier, as shown by blow Figure.

40. If closely observed, one can note that this circuit is just a combination of inverting and non-inverting amplifier.

41. Hence its output voltage will be equal to the sum of the output voltages produced by the Op-Amp circuit operating as an inverting amplifier and the Op-Amp circuit Operating as a non-inverting amplifier.

Thus, one gets,

$$V_0 = -\frac{R_f}{R_1}V_1 + V_2\frac{R_f}{R_2 + R_3}\left(1 + \frac{R_f}{R_1}\right)$$

Now, if R1 = R2 and R3 = Rf, then

$$V_0 = -\frac{R_f}{R_1}V_1 + V_2\frac{R_f}{R_1 + R_f}\left(\frac{R_1 + R_f}{R_1}\right)$$

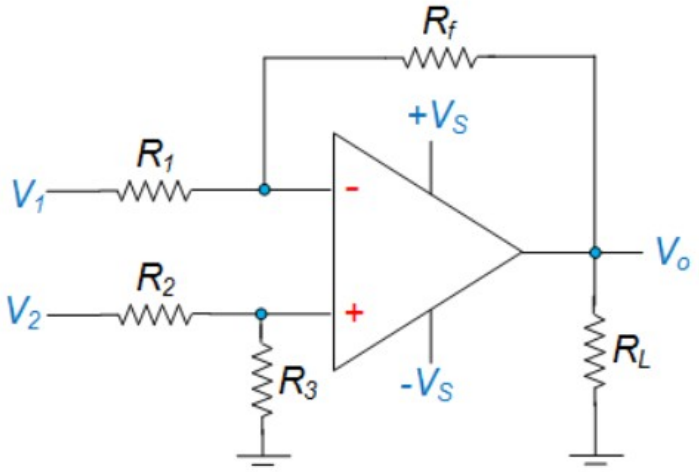


Fig 3.4 Differential amplifier

This implies that the gain of the **differential amplifier** circuit shown in above Figure is given by.

$$-\frac{R_f}{R_1}$$

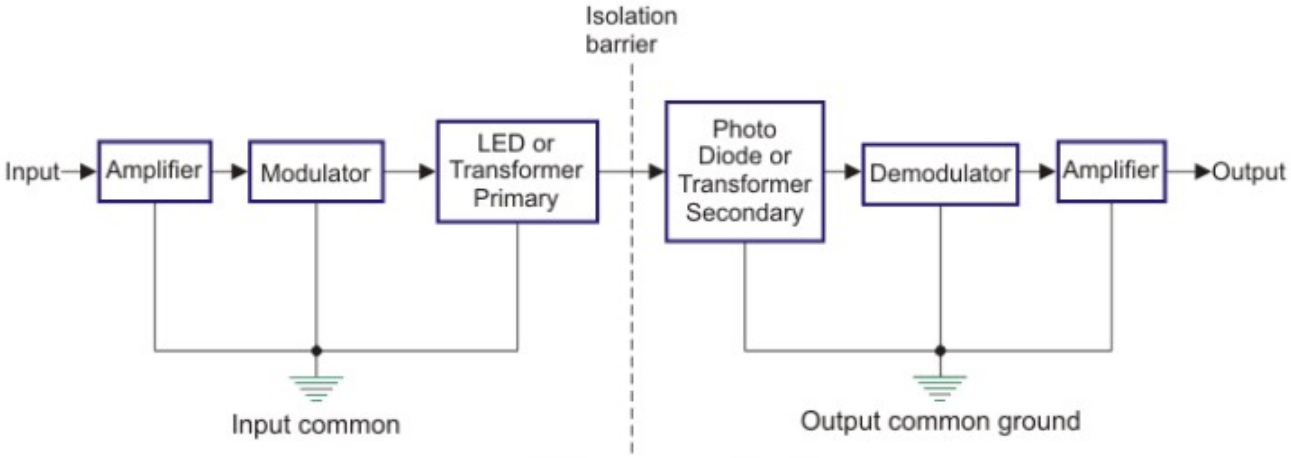
17. In addition, it is to be noted that the basic circuit shown by above Figure can be modified in many ways resulting in various circuit designs including Wheatstone bridge differential amplifier, light activated differential amplifier and instrumentation amplifier.

18. These devices are used as motor and/or servo controllers, signal amplifiers, analog multipliers, switches, volume controllers, automatic gain controllers, amplitude modulators, etc. and cover a wide range of applications including those in instrumentation systems, microphones, analog to digital converters applications.

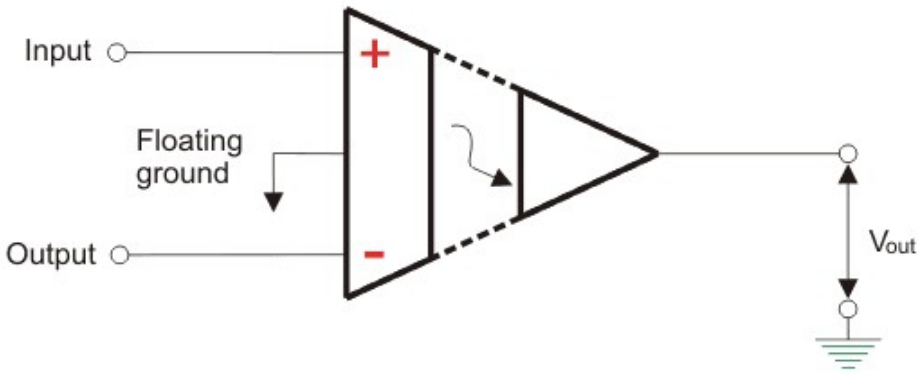
Isolation Amplifier

- Isolation amplifiers are known as Pre-amplifier isolation circuits.
- An isolation amplifier increases the input impedance of a patient monitoring system.
- It also helps to isolate the patient from the device.
- Using the isolation amplifier prevents accidental internal cardiac shock.
- It provides up to 1012 Ω insulation between the patient and the power line in the hospital.
- The electrical signals are obtained with electrodes. The signals received goes to the amplifier block, where signals amplification occurs.
- After amplification, the signal enters the modulation block. When either it goes to the isolation barrier, optical cable or transformer can be used.
- If in case of optical cable, modulator output travels to LED. The LED converts electrical signals into light energy.

- If the transformer acts an isolation barrier, modulator output connects the primary winding of the transformer.
- Energy from primary transfers to the secondary winding based on the mutual induction principle.
- At the next stage, secondary output enters the demodulation block. Finally, the amplified demodulated signal is obtained.



Block Diagram of Isolation Amplifier



Symbol of Isolation Amplifier

Fig 3.1 Isolation Amplifier

ECG Isolation Amplifier

- During ECG measurement, signals generated from all leads are sent to the low pass filter. This filter is named as Electro surgery filters because it decreases the interference between electro-surgery and radio frequency.
- Next block is the high voltage and overvoltage protection that can withstand large voltage during defibrillation.

- Proceeding further, it goes to Lead Selector Switch block, which selects the required configuration.
- Lead selection output goes to the DC amplifier. We have a transformer, whose primary winding is connected to the oscillator and secondary to rectifier and filter.
- ECG signal is modulated with the Synchronous modulator.
- The second transformer delivers the output from the synchronous modulator to the synchronous demodulator.
- The output from the demodulator is fed as input to the power amplifier.

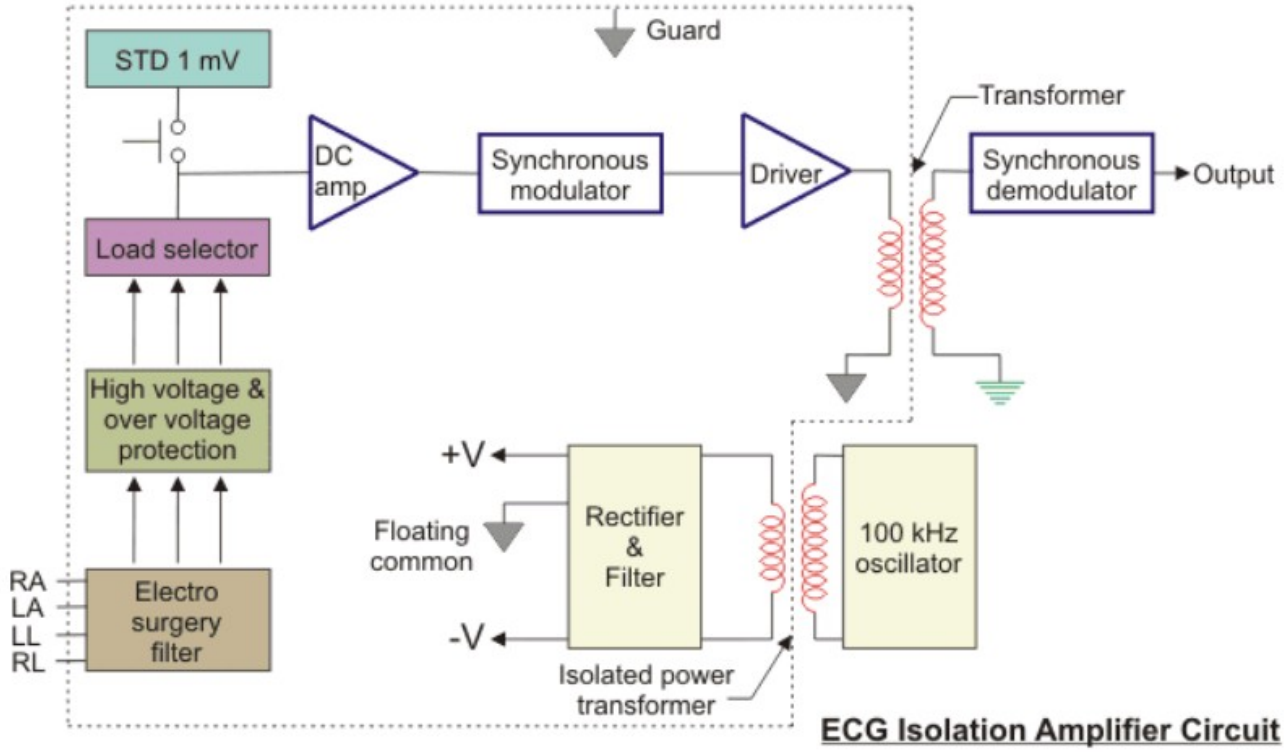


Fig 3.2 ECG isolation Amplifier circuit

UNIT IV MEASUREMENT OF NON-ELECTRICALPARAMETERS

1.Respiratory measurement

They are used to evaluate the state of lungs or respiratory process. The three basic types of measurement are ventilation, distribution and diffusion.

Ventilation:

- Ventilation deals with the determination of the ability of body to displace air volume quantitatively and the speed with which it moves the air.
- Spirometers are used in the ventilation measurement.

Distribution:

- It indicates the degree of lung obstructions for the flow of air and also determines the residual volume of air that cannot be removed from the lungs.
- Pneumatachomaters are used measure the instantaneous rate of volume flow of respired gases.

Diffusion:

- It indicates the lung ability to exchange gas with the circulatory system or the rate at which gas is exchanged with the blood stream.

Lung volumes and capacities

- Pulmonary function analyzers are used to determine the lung volumes and capacities. These parameters depend on individual's physical characteristics and condition of breathing mechanism.
- Lung capacities are indicated by milliliters and lung volumes are indicated by percentages.

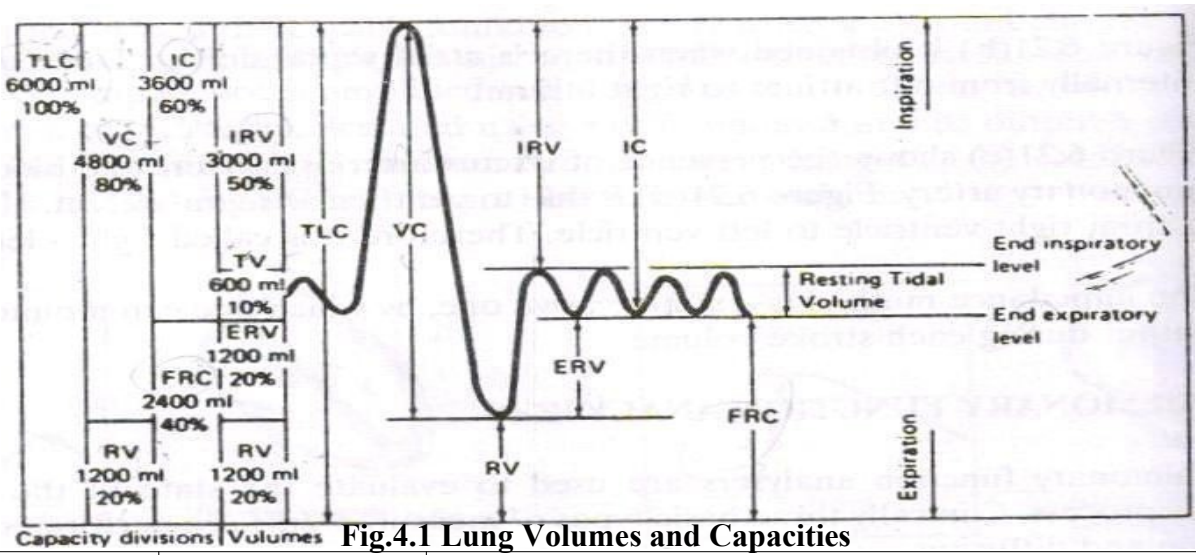


Fig.4.1 Lung Volumes and Capacities

Abbreviation	Full form	Definition
TLC	Total lung capacity	It is the total amount of gas contained in the lungs at the end of a maximal inspiration. It is the sum of vital capacity and residual volume.

VC	Vital capacity	Maximum volume of gas that can be expelled from the lungs after the maximal inspiration.
TV	Tidal volume	It is the volume of gas inspired or expired during each normal, quiet and respiration cycle.
RV	Residual volume	It is the volume of gas remaining in the lung at the end of a maximal expiration.
IRV	Inspiratory reverse volume	Extra volume of gas that can be inspired with maximal effort after reaching the normal end of inspiratory level.
ERV	Expiratory reverse volume	It is the extra volume of gas that can be expired with maximum effort beyond reaching the normal end of expiratory level.
IC	Inspiratory Capacity	It is the maximum amount of gas that can be inspired after reaching the end expiratory level.
FRC	Functional Residual Capacity	It is the volume of gas remaining in the lung at the end of expiratory level.
FVC	Forced vital capacity	It is the total amount of air that can forcibly be expired as quickly as possible after taking the deepest possible breath.
FEV	Forced Expiratory Volume	It is the maximum amount of gas that can be expelled at the given time.

2. Explain the different techniques used in measurement of pulse rate(A/M2018)

PULSE MEASUREMENT

18. When heart muscle contracts, blood are ejected from the ventricles and a pulse of pressure is transmitted through the circulatory system. This pulse can be measured at various points.

19. We can sense the pulse by placing our fingertip over the radial artery in the wrist. This pulse travels at the speed of 5 to 15m per second.

20. Photoelectric method is commonly employed to measure the pulse.

Types:

Photoelectric method consists of two types

42. Tramsmittance method

43. Reflectance method

TRANSMITTANCE METHOD OF PULSE MEASUREMENT

- LED and photo resistor are used in this method. These are mounted in a enclosure that fits over the tip of the finger.
- Light is produced by the LED. The same light is passed through the finger. For each heart pulse, blood is forced to the extremities and the amount of blood in the finger is increased.
- So optical density is changed. So, the light transmitted through the finger is decreased. This light is received by the photo resistor.

- This photo resistor is connected with the part of voltage divider circuit. The voltage produced by this circuit is directly proportional to the amount of blood flow in the figure.
- The output is recorded by using strip chart recorder.

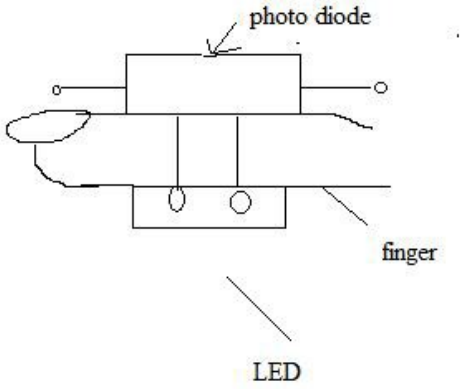


Fig.4.2 Transmittance Method Of Pulse Measurement

REFLECTANCE METHOD

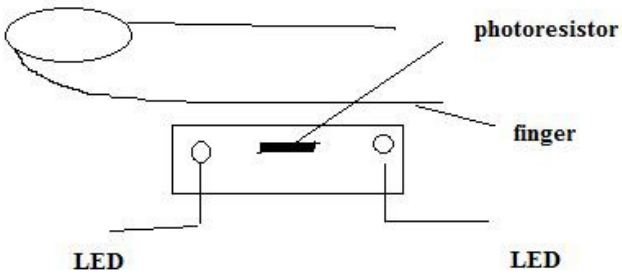


Fig.4.3 Reflectance Method

N reflectance method, LED is placed adjacent to the photo resistor. LED emits the light. This light is reflected form the skin and the tissues falls on the photo resistor. The reflected light varies depending upon the blood flow in the finger. The photo resistor is connected as a part of the voltage divider circuit. The output obtained is directly proportional to the amount of blood in the finger. The output can be recorder using strip chart recorder.

3. Blood pressure

The pressure of the blood in the circulatory system, often measured for diagnosis since it is closely related to the force and rate of the heart beat and the diameter and elasticity of the arterial walls.Pressure is defined as force per unit area,

P = F / A P = pressure in pascal,

F=Force,

A=Area

Thus pressure is increased by increasing the applied force or by decreasing the area.

Systolic blood pressure

When our heart beats, it contracts and pushes blood through the arteries to the rest of our body. This force creates pressure on the arteries. This is called systolic blood pressure. A normal systolic blood pressure is 120 or below.

Diastolic blood pressure

The diastolic pressure is specifically the minimum arterial pressure during relaxation and dilatation of the ventricles of the heart when the ventricles fill with blood. In a blood pressure reading, the diastolic pressure is typically the second number recorded.

Methods

1. Indirect method using sphygmomanometer
2. Direct method

Indirect Method using Sphygmomanometer:

- In this method Sphygmomanometer is used to measure blood pressure indirectly.
- It consists of inflatable rubber bladder which is known as cuff, rubber squeeze ball pump & Valve assembly.
- Pressure is measured using manometer with mercury column.

Procedure to use Sphygmomanometer:

- Cuff is wrapped around the patient‘s upper arm at a point midway between elbow & Shoulder.
- Stethoscope is placed over the brachial artery at the distal border, because at this place, brachial artery comes close to surface.
- Initially the pressure in the cuff is raised well above the systolic pressure so that the flow of blood is completely terminated.
- Then pressure in the cuff is released at a particular rate.
- When the pressure reaches below the systolic pressure a brief flow of blood occurs.
- If the cuff pressure falls further below the diastolic pressure the flow of blood becomes normal and uninterrupted.
- At an exact instant the artery just opens and when it is fully opened it makes a Korotkoff sound
- This Korotkoff sound appears when the cuff pressure falls just below the systolic pressure.

- The sound disappears just below diastolic pressure.
- These sounds are picked up by a microphone placed over an artery distal to the cuff.

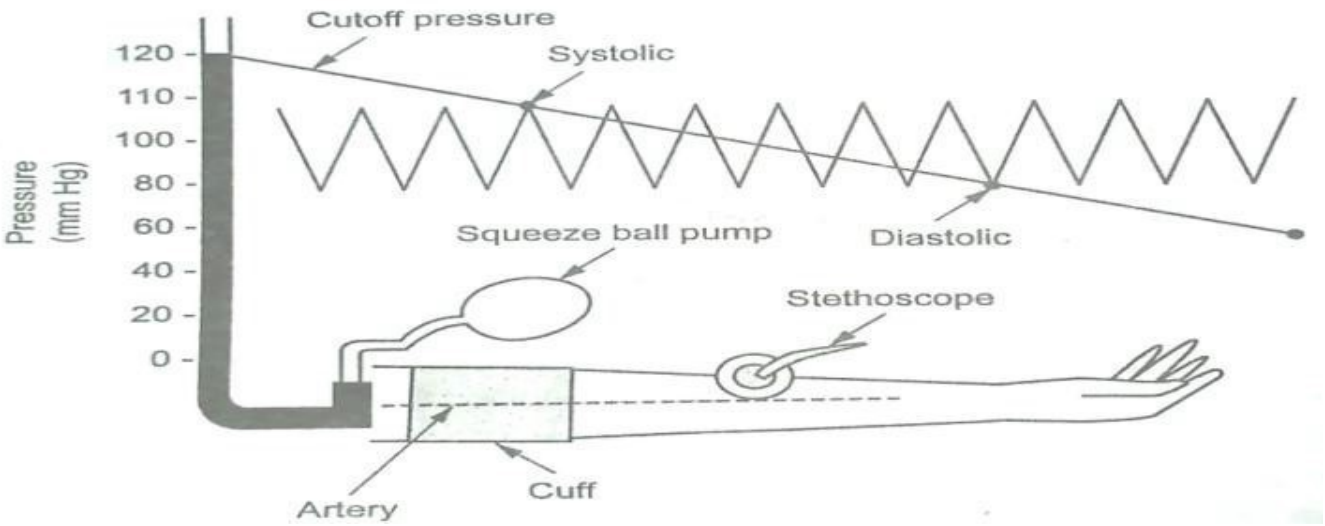


Fig.4.4 (a)Oscillometric or Ausculatory method

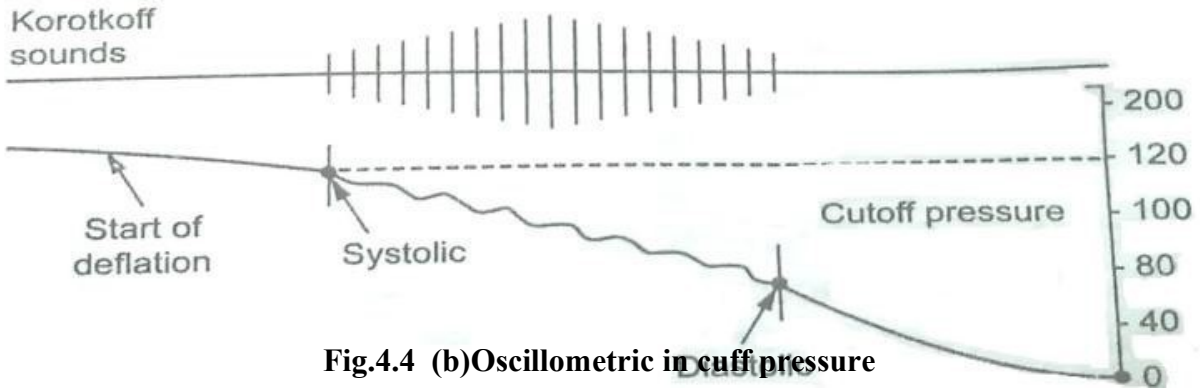


Fig.4.4 (b)Oscillometric in cuff pressure

Indirect method using sphygmomanometer

Thus the doctor slowly reduces the pressure in the cuff & he watches the mercury column when the systolic pressure exceeds the cuff pressure. Then doctor can hear some crashing, snapping sound through stethoscope. This sound is known as korotkoff sound.

Advantages

- Method is very simple
- Painless techniques
- There is no hazardous surgical procedure involved.

Disadvantages

Effective result depend on the fact how accurately doctor read pressure values when koratkoff sound is heard.

Direct Method of Blood Pressure Measurement:

- Direct method of blood pressure is used when highest degree of absolute accuracy, dynamic response and continuous monitoring is required.
- It is used to know blood pressures in deep regions which is inaccessible by indirect method.
- A catheter or a needle type probe is inserted through the vein or artery to the area of interest.
- Two types of probes are commonly used.
- One type has Catheter tip with sensor mounted at the tip of the probe. Pressure exerted on the tip is converted to the corresponding electrical signal.
- The other type is the fluid filled catheter type. Pressure exerted on the fluid filled column is transmitted to external transducer. This transducer converts pressure in to electrical signal.

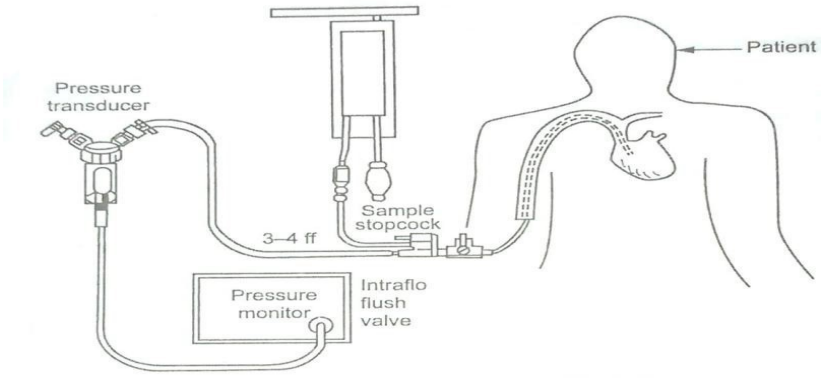


Fig.4.5 Direct blood pressure measurement

- A typical set up of a fluid filled system for measuring blood pressure is shown in Fig.4.5
- Here fluid filled catheter is used.
- Before inserting catheter into blood vessel, fluid filled system should be completely flushed out. Usually sterile saline is used for this purpose to avoid blood clotting in it.
- The system should be free from air bubbles.

Working:

Blood is taken from vessel using Cather tip probe. Pressure exerted is transmitted to the pressure transducer. The output of transducer is given to pressure monitor.

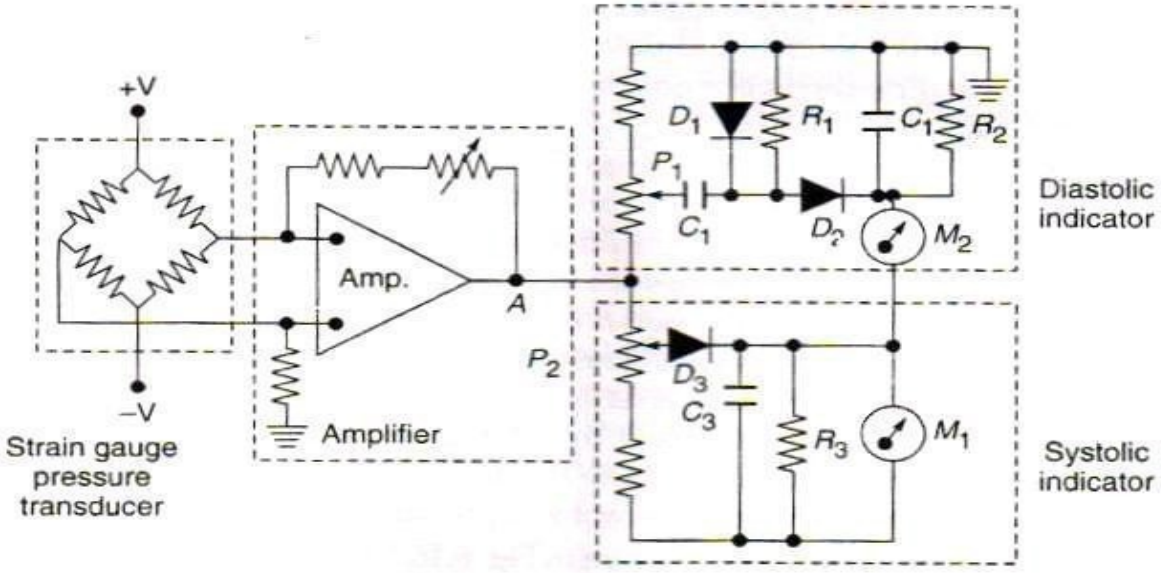


Fig.4.6 Circuit diagram for measurement of systolic and diastolic blood pressure

- Figure above shows a simplified circuit diagram commonly used for processing the electrical signals received from the pressure transducer for the measurement of arterial pressure.
- The transducer is excited with 5 V dc excitation.
- The electrical signal corresponding to the arterial pressure are amplified in an operational amplifier.
- For the measurement of systolic pressure, a conventional peak reading type voltmeter is used.
- The diastolic pressure is indicated by a second meter M2 in an indirect way.

  M2 reading = peak systolic value - peak to peak pressure value.

4.Explain the working principle of electromagnetic blood flow meter. What are its advantages and disadvantages? (May/June 2015)(May/June 2016) (May/June 2017)(Nov/ Dec2018)

BLOOD FLOWMETER

Blood flow meters are used to monitor the blood flow in various blood vessels and to measure cardiac output.

Types

- Electromagnetic blood flow meters
- Ultrasonic blood flow meters
- Laser based blood flow meters

ELECTROMAGNETIC FLOWMETERS

- Electromagnetic blood flow meters measure blood flow in blood vessels
- Consists of a probe connected to a flow sensor box

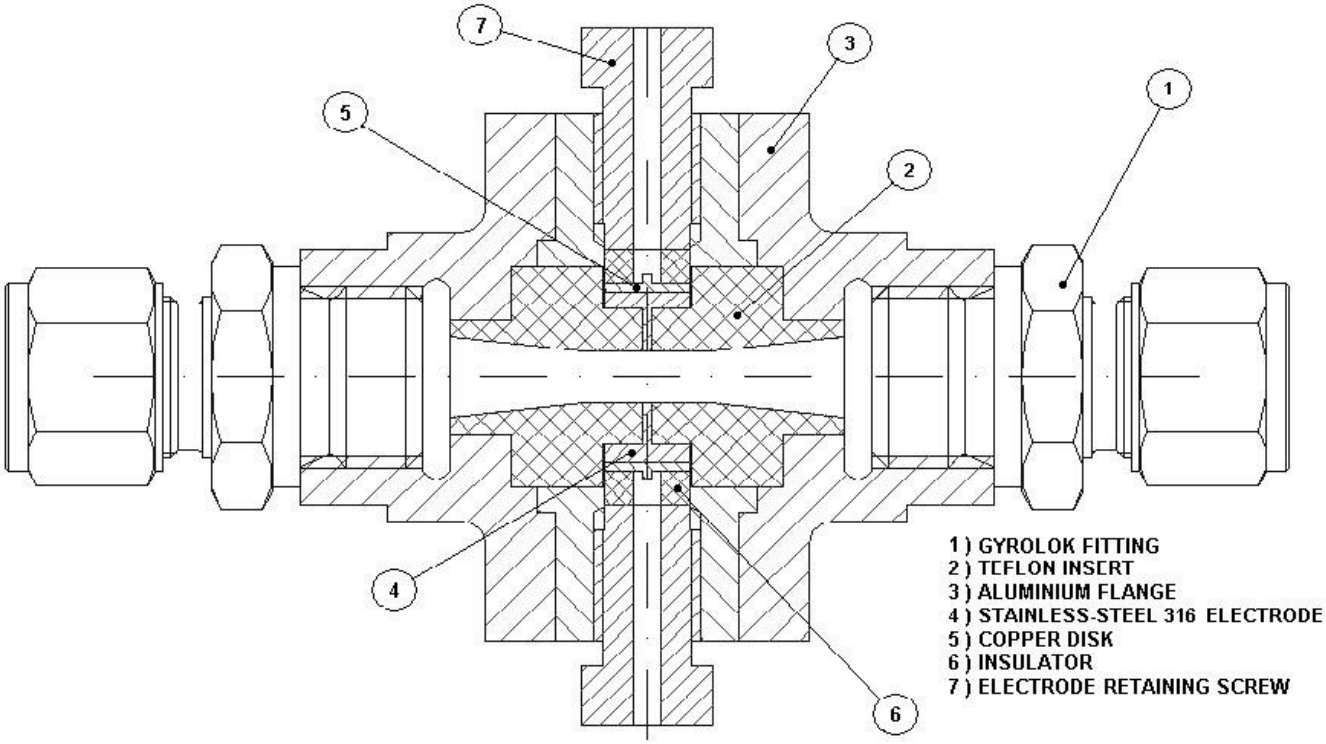


Fig.4.8 Electromagnetic flow meter

An Electromagnetic Flow Meter is a device capable of measuring the mass flow of a fluid. Unlike the common flow meter you can find on the market it has no moving parts, and for this reason it can be made to withstand any pressure (without leakage)and any fluid(corrosive and non corrosive). This kind of flow meter use a magnet and two electrodes to peek the voltage that appears across the fluid moving in the magnetic field.

The Neumann Law (or Lenz Law) states that if a conductive wire is moving at right angle through a magnetic field, a voltage ***E*** [Volts] will appear at the end of the conductor

E=B*L*V

Where

B = Magnetic Induction

[Weber/m2]

L = Length of the portion of the wire 'wetted' by the magnetic field [m]

V = Velocity of the wire [m/sec]

Fig.2

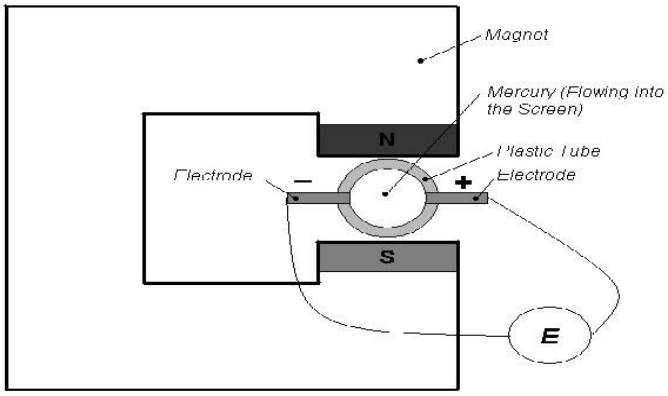


Fig.4.9 Magnetic Blood flow meter principle

Now imagine you have a plastic tube with two electrodes on the diameter and Mercury flowing into it. A voltage will appear on the electrodes and it will be

E=B*L*V

As in the previous example (***L*** in this case is the inner diameter of the tube).Mercury as tiny conductive wires next to each other: each wire, moving in the tube, will touch the two elec-trodes, and thus you can measure their voltage.

An interesting fact is that if you reverse the flow, you still get a voltage but with reverse polarity (Fig.1). Till now we have talked about a conductive fluid ,Mercury, but this stuff will also work with non-conductive fluid, provided that you use an alternating magnetic field. Two physicists, Middleman and Cushing, in an unpublished work, stated that when using a non-conductive fluid, if the frequency of the alternating magnetic field is ***v*** the voltage at the electrodes will be attenuated by a factor ***a*** so that:

Measuring the flow

A perfect axisymmetric construction cannot be achieved and thus some magnetic flux lines will 'wet' the connecting wires to the electrodes. The alternating magnetic field will create an offset voltage in this wire and even if the fluid is not moving, the measured voltage will not be zero.

ULTRASONIC FLOWMETERS

The blood cells in the fluid scatter the Doppler signal diffusively. In the recent years ultrasound contrast agents have been used in order to increase the echoes. The ultrasound beam is focused by a suitable transducer geometry and a lens.

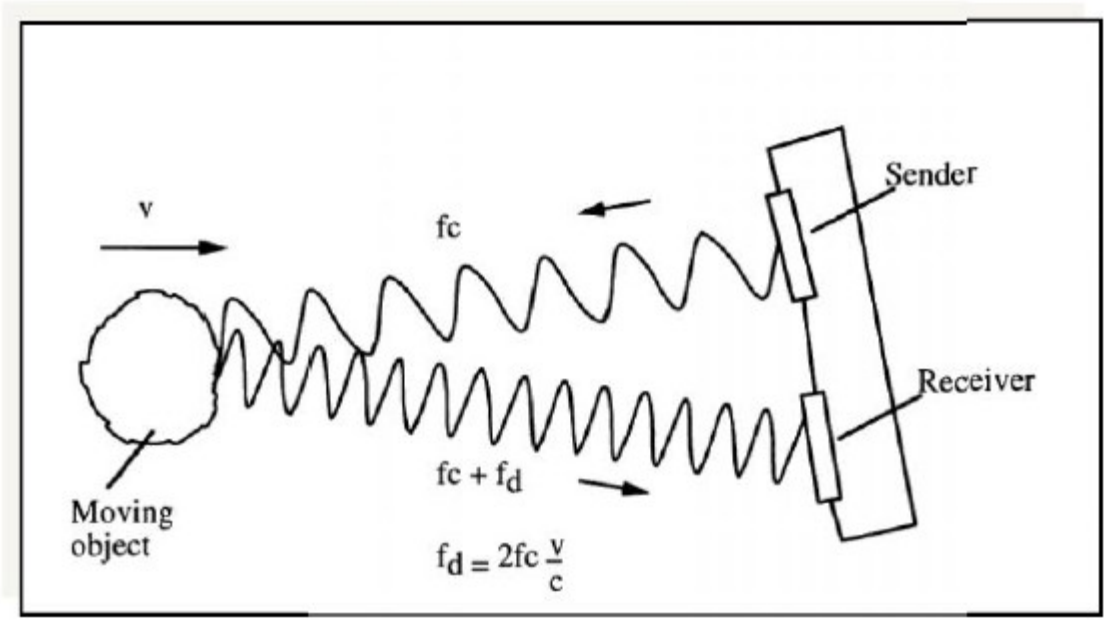


Fig.4.10 Ultrasonic flow meter

fd = 2fcv/c
f = 2- 10 MHz
c = 1500 - 1600 m/s (1540 m/s)
f = 1,3 – 13 kHz

In order to know where along the beam the blood flow data is collected, a pulsed Doppler must be used. The flow velocity is obtained from the spectral estimation of the received Doppler signal. The ultrasound Doppler device can be either *a continuous* wave or a pulsed Doppler.

A Continuous Wave

- No minimum range
- Simpler hardware
- Range ambiguity
- Low flow cannot be detected

A Pulsed Doppler

18. Accuracy
19. No minimum flow
20. Minimum range

(Maximum flow) x (range)= limited the power decays exponentially because of the heating of the tissue. The absorption coefficient ~ proportional to frequency the far field operation should be avoided due to beam divergence.

Dnf = D2/ 4

D = Transducer diameter (e.g. 1 – 5 mm) the backscattered power is proportional to *f* .The resolution and SNR are related to the pulse duration. Improving either one of the parameters always affects inversely to the other.

LASER DOPPLER FLOWMETRY

The principle of measurement is the same as with ultrasound Doppler. The laser parameter may have the following properties:5 mWHe-Ne-laser 632,8 nm wavelength.

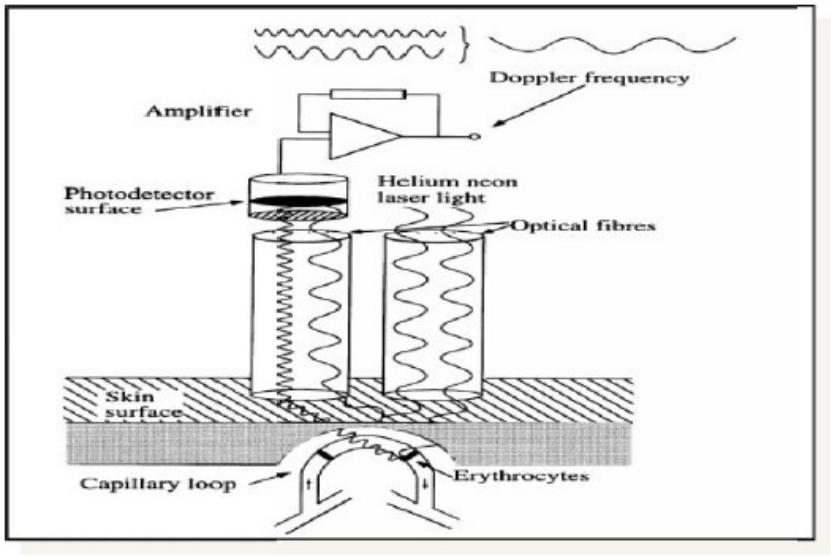


Fig.4.11 Laser Doppler flow meter

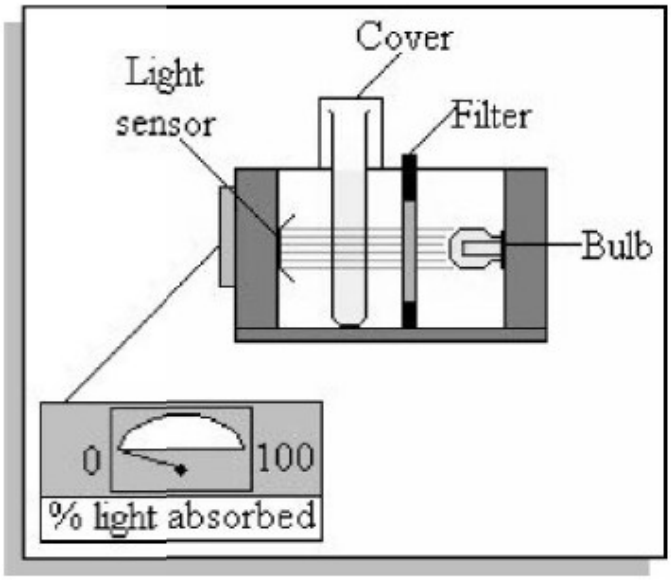
The moving red blood cells cause Doppler frequency 30 – 12 000 Hz. The method is used for capillary (microvascular) blood flow measurements

5.Define the term "Cardiac Output". How is cardiac output measured by dye dilution technique? Explain. (May/June 2017)(Nov/Dec 2018)

Indicator Dilution Methods

Dye Dilution Method

A bolus of indicator, a colored dye *(indocyanine green),* is rapidly injected in to the vessel. The concentration is measured in the downstream The blood is drawn through a colorimetric cuvette and the concentration is measured using the principle of absorption photometry.



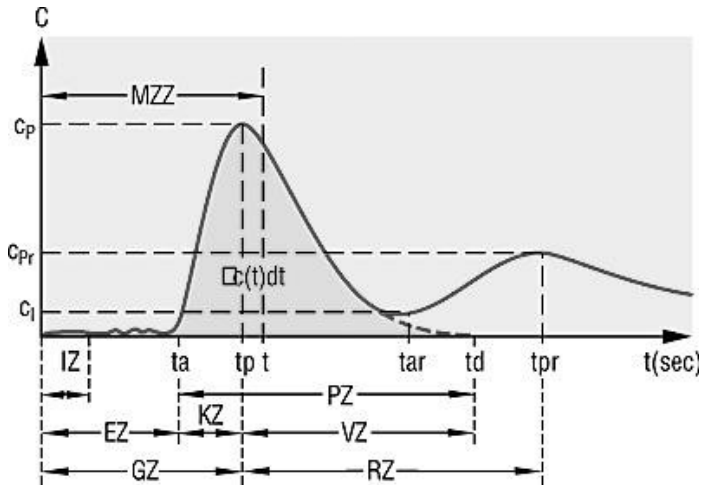


Fig.4.12 Dye Dilution method

Thermal Dilution Method

A bolus of chilled saline solution is injected into the blood circulation system (right atrium). This causes decrease in the pulmonary artery temperature. An artery puncture is not needed in this technique .Several measurements can be done in relatively short time .A standard technique for measuring cardiac output in critically ill patients.

CARDIAC OUTPUT

- It is the amount of blood delivered by th heart to the aorta per minute.
- In the case of adult the amount of blood pumped ranges from 70 to 100ml in each beat. Hence for normal adult the cardiac output is about 4- 6 liters / min.
- Decrease in cardiac output is due to low blood pressure, reduced tissue oxygenation, poor renal function, shock and acidosis.

Two methods are available

(i) Direct method (ii) In direct method electromagnetic flow probe

is implanted on the aorta by surgery. It is the product of stroke volume and heart

beat rate per minute)

(ii) Indirect method

Flick's Method:

- This is based on the determination of cardiac output by the analysis of gas-keeping of the organism.
- It is calculated by continuously infusing oxygen into the blood or removing it from the blood and measuring the amount of oxygen in the blood before and after its passage.
- I = CAQ - CVQ

  I– amount of infused or removed oxygen per unit time.

  CA, CV – Concentration of oxygen in atrial blood (outgoing) and mixed venous blood (incoming blood) respectively. Q – Cardiac output. Therefore, Q=I/(CA-CV)
- The oxygen consumption is determined by analyzing the exhaled air collected in a bag during 10 min.
- CV is measured by taking samples from a central vein through a cardiac catheter.
- CA is analyzed by taking samples from artery in fore arm.

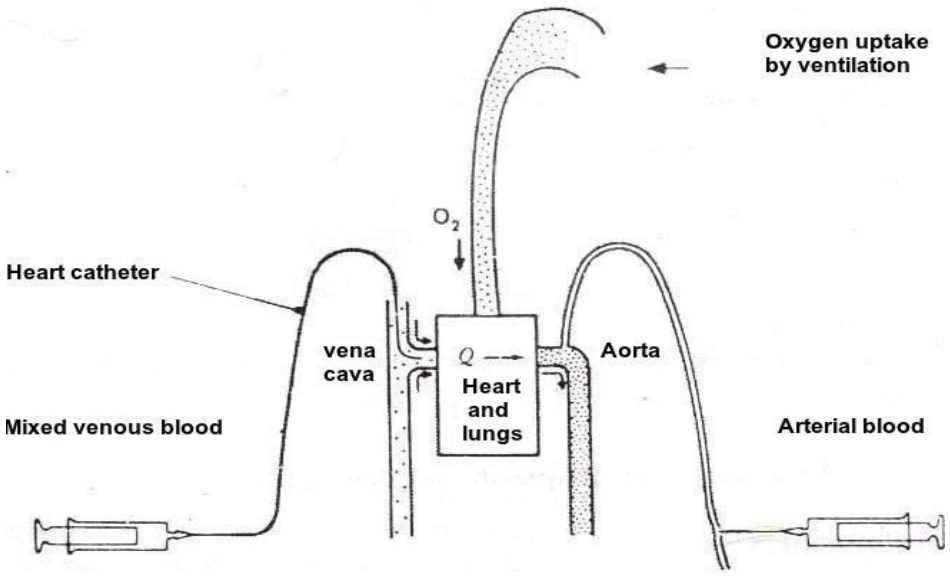


Fig.4.16 Flick's method

Indicator Dilution Method:

- This is based on the principle that if we introduce an indicator (dye or radioisotope) in the blood circulation and then measuring the concentration of indicator with respect to time, we can estimate the volume flow of blood.
- Let M mg of an indicator is injected into the right heart.

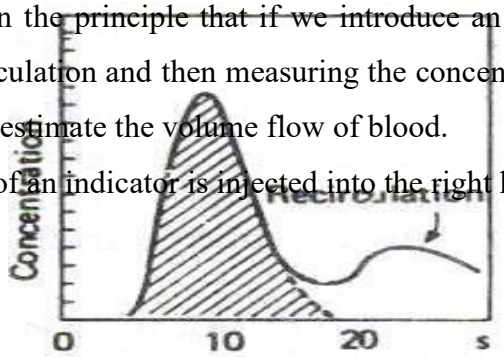


Fig.4.17 Dilution curve

- During the first circulation period, the indicator would mix up with the blood in a small quantity.
- After that there is a rapid change of concentration. This is shows by rising portion of dilution curve. After reaching maximum, the concentration of indicator decreased exponentially.
- When the indicator is completely mixed up with the blood the curve becomes parallel with the time axis.

  Cardiac output, Q= M/ Area of the curve
- Indicator dilution is more useful when there is no severe heart defect. Here the diagnostic information can be obtained from the changes in the shape of dilution curve.

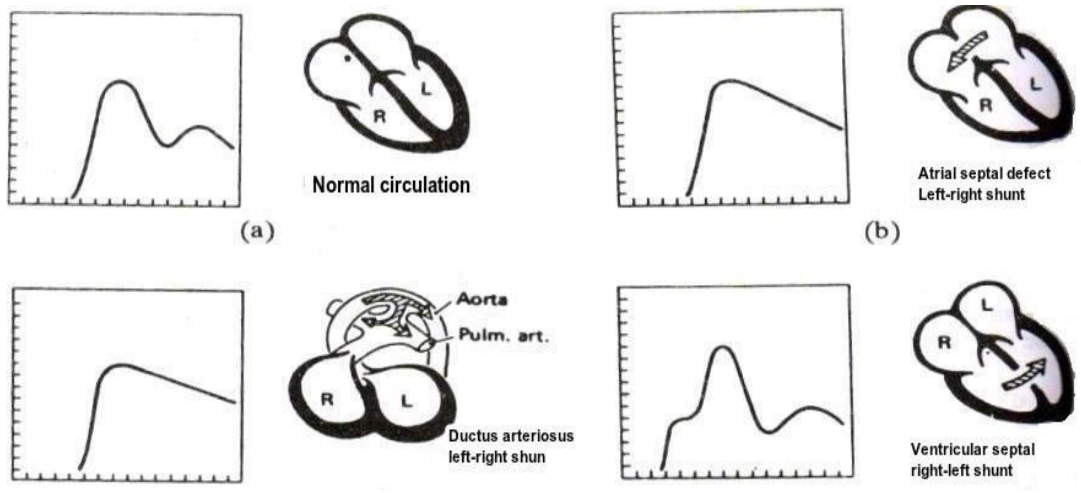


Fig.4.18 Dye dilution curves during presence of shunts

Fig. (a) shows the normal curve corresponding to the normal circulation of blood

Fig (b) shows atrial septal defect where blood flows internally from left atrium to right atrium.

Fig (c) shows ductus arterisous. Here blood flows from aorta to pulmonary artery.

Fig. (d) is due to ventricular septal defect (right left shunt). Here blood is flowing from right ventricle to left ventricle.

Disadvantages

- Foreign substances may be injected into the blood when the blood is taken for analysis.

Thermo Dilution Method

- Now-a-days thermo dilution method is adapted to measure cardiac output.
- A large pill of about 10 mL of 5 % Dextrose in water at room temperature is injected as a thermal indicator in right atrium.

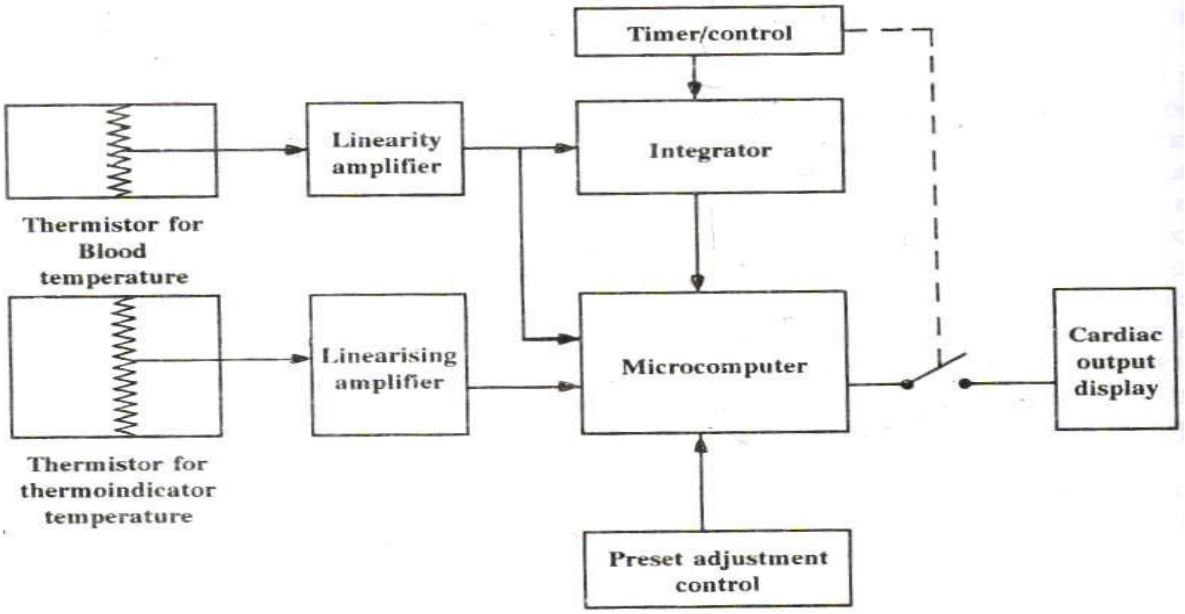


Fig. 4.19 Block diagram of thermo dilution system

After mixing, it is detected in the pulmonary artery by a catheter probe.

- The temperature difference between the injected temperature and the circulating blood temperature in the pulmonary artery is measured.
- After proper correction the meter reads the cardiac output.
- A linear relation between temperature and resistance of the thermistor can be maintained by connecting a parallel resistor with it.
- Based on this fact the linearizing amplifier works.
- Integrator delivers the value of integral of blood temperature change over a given time.
- By feeding data about the density and specific heat of blood and thermal indicator and volume of thermal indicator injected can deliver the cardiac output in lit/ min.

Measurement of cardiac output by impedance change

- By the impedance method, the cardiac output can be determined electronically.
- 4 probes method is adopted here. The electrode pair 1 & 4 is used as current electrodes.

- The electrode pair 2 & 3 are used to pick up the voltage across the thorax
- The electrode pair 2 & 3 is used to pick up the voltage across the thorax.
- If ρ ----resistivity of the patients hematocrit (the ratio of the volume of red blood cells to the total volume of blood),

  A ---- area of cross section of the thorax,
  L----- separation between the potential electrode 2 and 3. The resistance of the thorax is given by,
  $R = \rho L/A$
  $= \rho L^2/AL$
  $= \rho L^2/V$

or $V = \rho L^2/R$
V---Volume of the thorax.

$dV = -\rho (L^2/R^2) dR$

By determining dV the cardiac output can be measured by multiplying dV with heart beat rate per minute.

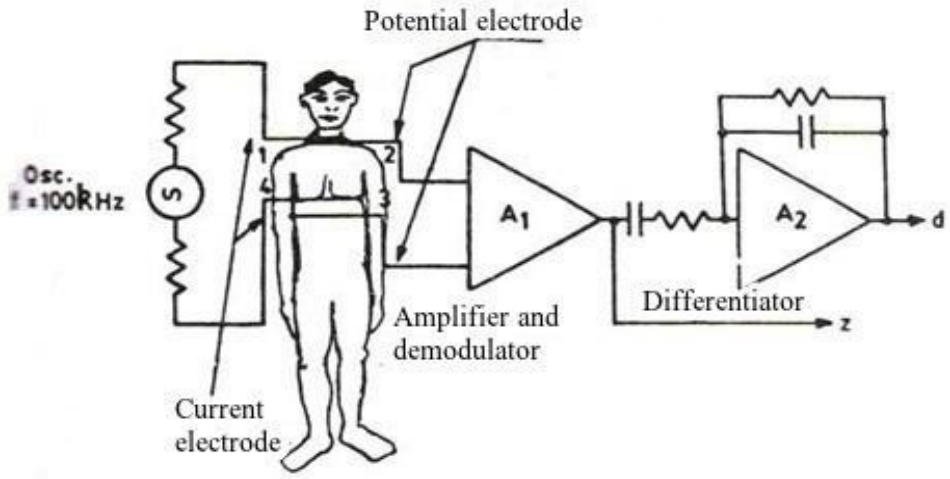


Fig.4.20 Measurement of Cardiac Output by Impedance Change

Advantages

- The impedance method is a noninvasive one (involving the introduction of instruments or other objects into the body or body cavities), by which one can monitor the cardiac output during each stroke volume.

[Stroke volume (SV) is the amount of blood pumped out of the heart during each contraction measured in mL/beat (milliliters per beat)]

UNIT V BIO-CHEMICAL MEASUREMENT

1.Explain the principle of following: pH measurement (May/June 2016) (May/June 2018) and auto analyzer (May/June 2011) (Nov/Dec 2017)

pH Measurement:

The chemical balance in the body can be determined by the ph value of blood and other body fluids.ph is defined as the hydrogen ion concentration of a fluid. It is the logarithm of the reciprocal value of h+ concentration. The ph equation is given as,

pH= - log10 [H+] = log10 1/[H+]

pH is the measure of acid- base balance in a fluid, A neutral solution has the ph value as 7. Solutions with pH value less than 7 are acidic and above 7 are basic. Most of the body fluids are slightly basic in nature.

Construction and working

The ph meter is made up of a thin glass membrane and it allows only the hydrogen ions to pass through it. The glass electrode provides a membrane interface for H+ ions. The glass bulb at the lower end of the ph meter contains a highly acidic buffer solution. The glass tube consists of a sliver-sliver chloride (Ag/Agcl) electrode and the reference electrode which is made up of calomel sliver-sliver chloride(Ag/Agcl) is tan placed in the solution in which ph is being measured.

The potential is measured across the two electrodes. The electrochemical measurement, which should be obtained by each of the electrodes called half- cell. The electrode potential is called as half-cell potential. Here the glass electrode inside the tube constitutes one half –cell and the calomel or reference electrode is considered as the other half-cell.

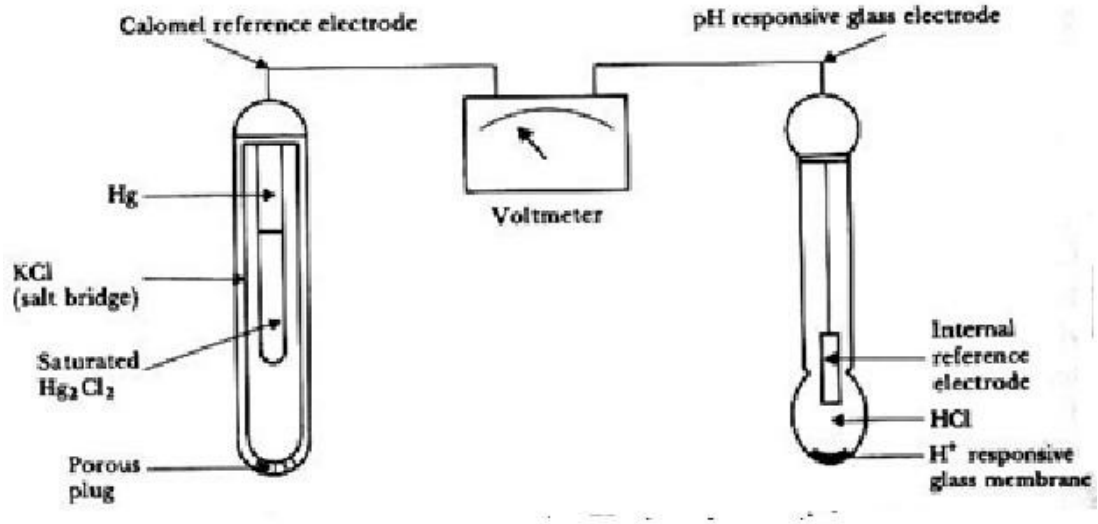


Fig.2.1 pH Electrode

For easier ph measurement combination electrodes are used. In this type both the active glass electrode and reference electrode are present in the same meter. The glass electrodes are suitable only to measure ph values around 7. Since this type of glass electrodes produce considerable errors during the measurement of high Ph values, special type of Ph electrodes are used. After every measurement the pH meter is washed with 20% ammonium biflouride solution, for accurate results. The Ph meter with hydroscopic glass absorbs water readily and provides best pH value.

2.Describe the measurement of PO_2. (May/June 2017) (Nov/Dec 2017) (April/May2018)

pO2 MEASUREMENT

The term po2 is defined as the partial pressure of oxygen respectively. The determination of po2 is one the most important physiological chemical measurement. The effective functioning
of both respiratory and cardiovascular system can be by po2 measurement. The partial pressure of
a gas is proportional to the quantity of that gas present in the blood.
The platinum wire, which is an active electrode, is embedded in glass for insulation and only its tip is exposed. It is kept in the electrolyte solution in which the oxygen is allowed to diffuse. The reference electrode is made up of silver-silver chloride (Ab/AgCl). A voltage of 0.7 is applied between the platinum wire and the reference electrode. The negative terminal is connected to the active electrode through a micro ammeter and the positive terminal is given to the reference electrode.

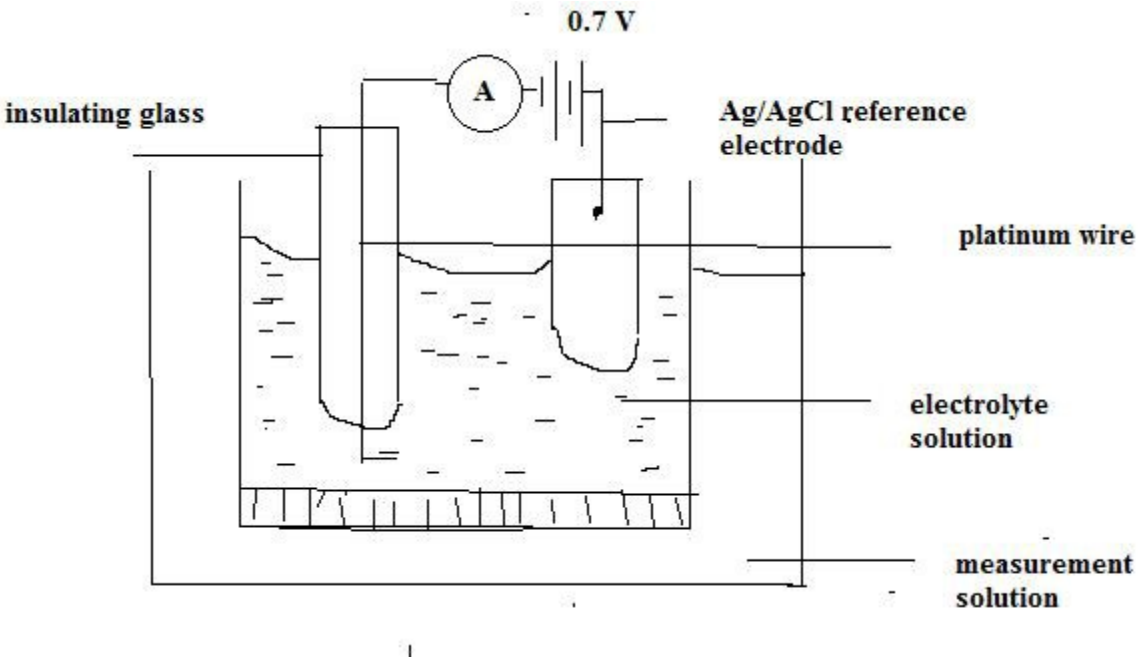


Fig.2.2 pO2 Electrode

Due to the negative terminal, the oxygen reduction takes place at the platinum cathode. Finally the oxidation reduction current proportional to the partial pressure of oxygen diffused into the electrolyte can be measured in the micro ammeter. The electrolyte is generally scaled in the electrode chamber by means of a membrane through which the oxygen can diffuse from the blood or sample solution.

There are two types of pO2 measurement. They are

I) Vitro measurement

II) Vivo measurement

In case of dark electrode the platinum cathode and the reference electrode is present in a single unit. This electrode is used for vitro and vivo measurements.

In Vitro Measurements

In this method the blood sample is taken and the measurement for oxygen saturation is made in the laboratory. The electrode is placed in the sample blood solution and the pO2 value is determined.

In Vivo Measurements

In this method the oxygen saturation is determined while the blood is flowing in the circulatory system. A micro version of the pO2 electrode is placed at the tip of the catheter so that it can be inserted into various parts of the heart or circulatory system.

The pO2 measurement also has some disadvantages in it. The reduction process in the platinum cathode removes a finite amount of the oxygen from the cathode. And there is a gradual reduction of current with respect to time. However careful design and proper procedures in modern pO2 electrodes reduce the errors.

pCO2 MEASUREMENT

The term pco2 is defined as the partial pressure of carbon dioxide respectively. The determination of pco2 is one the most important physiological chemical measurement. The effective functioning of both respiratory and cardiovascular system can be by pco2 measurement. The partial pressure of a gas is proportional to the quantity of that gas present in the blood.

The partial pressure of carbon dioxide can be measured with the help of pCO2 electrodes. Since there is a linear relationship between the logarithm of pCO2 and pH of a solution. The pCO2 measurement is made by surrounding a pH electrode with a membrane selectively permeable to CO2.

The modern improved pCO2 electrode is called as severinghous electrode. In this electrode the membrane permeable to CO2 is made up of Teflon which is not permeable to other ions which affects the pH value. The space between the Teflon and glass contains a matrix layer which allows only the CO2 gas molecules to diffuse through it.

One of the demerits in older CO2 electrode is, it requires a length of time for the CO2 molecules to diffuse through the membrane. The modern CO2 electrode is designed in such a way to overcome this demerit. Here the CO2 molecules diffuse rapidly through the membrane and the measurement can be done easily.

3.Explain the following: (i) Colorimeter (April/May2019) (ii) Auto analyzer (April/May2017)(Nov/Dec 2017)

COLORIMETER

- Measures the color concentration of a substance in a solution by detecting the color light intensity passing through a sample containing the substance and a reagent
- Optical color filters are used to detect the color wavelength of interest. E.g., urine passes yellow light and absorbs blue and green
- Laser LEDs are preferred if their wavelength is suitable due to purity of the monochromatic color.

Fig2.3 Colorimeter

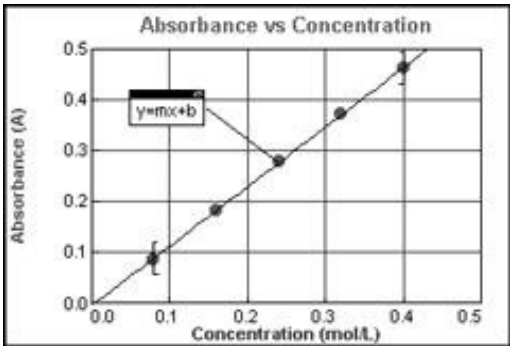


Fig.2.4 Concentration VS Absorbance

Transmittance

T= I1/I0 * 100%

Absorbance

A= - log I1/ I0

A=log 1/T

If the path length or concentration increases, the transmittance decreases and absorbance increases, a phenomenon expressed by Beer's Law.

Absorbtivity related to the nature of the $A=aCL$ absorbing substance and optical wavelength (known for a standard solutionconcentration).

C: Concentration

L: Cuvette path length

AUTOANALYZER

An auto analyzer sequentially measures blood chemistry through a series of steps of mixing,

reagent reaction and colorimetric measurements.

Itconsists of

- **Sampler:** Aspirates samples, standards, wash solutions into the system
- **Proportioning pump:** Mixes samples with the reagents so that proper chemical color reactions can take place, which are then read by the colorimeter
- **Dialyzer:** separates interfacing substances from the sample by permitting selective passage of sample components through a semi permeable membrane
- **Heating bath:** Controls temperature (typically at 37 °C), as temp is critical in color development
- **Colorimeter:** monitors the changes in optical density of the fluid stream flowing through a tubular flow cell. Color intensities proportional to the substance concentrations are converted to equivalent electrical voltages.
- **Recorder:** Displays the output information in a graphical form.

4.Write the principle of coulter counter with block diagram.Explain multi parameter coulter counter.(N/D2017)(A/M 2019)

BLOOD CELL COUNTER

• The blood cell counter counts the number of RBC or WBC per unit of volume of blood using either of two methods:

– Electrical method called aperture impedance change

– Optical method called flow cytometry

Aperture impedance change

• When blood is diluted in the proper type of solution, the electrical resistivity of blood cells (ρc) is higher than the resistivity of the surrounding fluid (ρf)

• By contriving a situation in which these resistivities can be differentiated from each other, we can count cells

Blood cell sensing

• The sensor consist of a two-chamber vessel in which the dilute incoming blood is on one side of barrier, and the waste blood to be discarded is on the other

• A hole with a small diameter (50μm) is placed in the partition between the two halves of the cell

• Ohmmeter measure the change on the resistance when the blood cell pass the aperture.

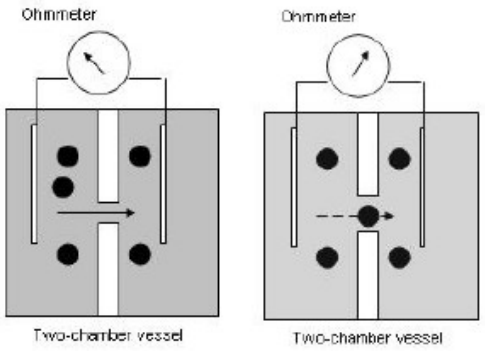


Fig.2.26 Blood cell sensing

COULTER COUNTER

• Constant current source (CCS) and voltage amplifier replace the ohmmeter

• RA is the resistance of the aperture and will be either high or low, depending on whether or not the blood cell is inside the aperture.

• Amplifier convert the current pulse to voltage pulse

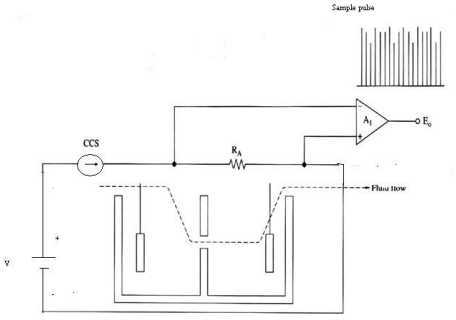


Fig. 2.27 Block diagram of coulter counter

Reg. No. : | | | | | | | | | | | | |

Question Paper Code : 52883

B.E./B.Tech. DEGREE EXAMINATIONS, APRIL/MAY 2019.

Sixth Semester

Electronics and Communication Engineering

EC 6001 — MEDICAL ELECTRONICS

(Regulation 2013)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. List the types of bioelectric potentials.

2. Name the electrodes used for recording EMG and ECG.

3. What are the typical values of blood pressure and pulse rate of an adult?

4. What is cardiac output? What are the methods of measurement of cardiac output?

5. Calculate the energy stored in 16 μF capacitor of a DC defibrillator that is charged to a potential of 5000 Vdc.

6. What are the types of batteries used for implantable pacemaker?

7. Draw the block diagram of a Bio-Telemetry system.

8. What is a radio-pill?

9. Define – Endoscopes and mention some of its types.

10. What is medical thermography'? Mention its applications.

PART B — (5 × 13 = 65 marks)

11. (a) Explain in detail the origin of bio potential. (13)

Or

(b) Draw the typical ECG waveform with its characteristics. (13)

12. (a) Describe in detail the principle of calorimeter with neat diagram. (13)

Or

(b) Explain the working principle of conductive method blood cell counter with its construction details. (13)

13. (a) With a neat diagram, illustrate the working of D.C. defibrillator. (13)

Or

(b) Write a brief note on heart lung machine. (13)

14. (a) What are the components of biotelemetry system? Briefly discuss about biotelemetry. (13)

Or

(b) Draw the block diagram of short wave and Microwave diathermy and explain in detail. (13)

15. (a) Write a brief note on Lasers in Medicine. (13)

Or

(b) What is thermography? Elucidate it in detail. (13)

PART C — (1 × 15 = 15 marks)

16. (a) What are the different types of ultrasonic blood flow meter? Explain each in detail. (15)

Or

(b) Explain about the evolution and technologies involved in telemedicine. And discuss the application areas of telemedicine. (15)

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Reg. No. : | | | | | | | | | | | | |

Question Paper Code : 71701

B.E./B.Tech. DEGREE EXAMINATION, APRIL/MAY 2017.

Sixth Semester

Electronics and Communication Engineering

EC 6001 — MEDICAL ELECTRONICS

(Regulations 2013)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Define absolute and relative refractory period.

2. Mention the cause of first and second heart sounds.

3. What is blood pressure? State the normal values of blood pressure.

4. State the different types of test performed using auto analyser.

5. Differentiate internal and external defibrillator.

6. What is dialyasate? Mention it Composition.

7. Define desiccation and haemostasis.

8. List the applications of biotelemetry.

9. What makes thermograph useful?

10. List the properties of LASER beam.

PART B — (5 × 16 = 80 marks)

11. (a) (i) Explain the international standard 12 lead system used to record ECG. (10)

(ii) List and discuss the important characteristics of bioamplifier. (6)

Or

(b) (i) Discuss in detail about the 10 - 20 lead system. (10)

(ii) Describe the typical EMG waveform and its characteristics. (6)

12. (a) (i) Describe the measurement of PO_2. (8)

(ii) Explain the block diagram and working of colorimeter. (8)

Or

(b) (i) Define the term "Cardiac Output". How is cardiac Output measured by dye dilution technique? Explain. (8)

(ii) Describe the working of principal of electromagnetic blood flow meter. (8)

13. (a) (i) With a neat diagram explain the block diagram of DC defibrillator. (8)

(ii) Describe the working of atrial synchronous pacemaker. (8)

Or

(b) Explain in detail the different types of oxygenators and pumps used in heart lung machine. (16)

14. (a) (i) Explain the simplified circuit diagram of a microwave diathermy machine. (10)

(ii) Discuss the different methods of applying electrodes in shortwave diathermy treatment. (6)

Or

(b) (i) Describe the single channel ECG telemetry system. (8)

(ii) Briefly discuss about micro and macro shocks. (8)

15. (a) (i) What is endoscope? Explain the different types of operations performed using endoscopy. (10)

(ii) Describe the working principle of thermograph. (6)

Or

(b) (i) Explain the different types of LASER. (10)

(ii) Write short notes on cryogenic applications. (6)

Reg. No. : | | | | | | | | | | | | |

Question Paper Code : 40928

B.E./B.Tech. DEGREE EXAMINATION, APRIL/MAY 2018
Sixth Semester
Electronics and Communication Engineering
EC 6001 – MEDICAL ELECTRONICS
(Regulations 2013)

Time : Three Hours | Maximum : 100 Marks

Answer ALL questions

PART – A (10×2=20 Marks)

1. What are the requirements of bio amplifiers ?
2. State the importance of PCG signals.
3. What is colorimeter ? State its uses.
4. Define cardiac output. What are the methods used to measure cardiac output ?
5. What is the function of haemodialysis system ?
6. What types of electrodes are used in a defibrillator ?
7. List the devices used to protect against electrical hazards.
8. What does the term fulguration refer to ?
9. Define medical thermograph.
10. Mention the advantages of performing surgery using laser.

PART – B (5×13=65 Marks)

11. a) i) Draw the equivalent circuit of biopotential electrode interface and explain about half cell potential. (5)

ii) Explain the different types of electrodes used in biopotential measurement. (8)

(OR)

b) i) Draw and explain the 10-20 electrode system used for EEG measurement. (8)

ii) Explain the different lead systems used in an ECG recorder. (5)

12. a) Discuss about the measurement of pH and pO_2 of the blood with the help of neat diagrams. (13)

(OR)

b) Explain the different techniques used in the measurement of pulse rate. (13)

13. a) Explain the different modes of cardiac pacemakers. (13)

(OR)

b) i) Explain the principle and operations of dc defibrillators. (6)

ii) Elucidate the application of heart lung machine during open heart surgery. (7)

14. a) Explain the following :

i) Short-wave diathermy. (6)

ii) Microwave diathermy. (7)

(OR)

b) i) What is radio pill ? (5)

ii) Draw the block diagram of single channel ECG telemetry system and explain the components. (8)

15. a) i) Write short notes on Helium-Neon Laser and its general applications in medicine. (8)

ii) What is an endoscope ? With diagram, discuss its working. (5)

(OR)

b) i) Write notes on cryogenic surgery. (5)

ii) Explain how telemedicine helps the patients and medical practitioners. (8)

PART – C

(1×15=15 Marks)

16. a) Compare the signal characteristics of ECG, EEG, EMG and PCG. (15)

(OR)

b) What is the need of electrical safety in hospital ? Discuss the various physiological effects of electricity. (15)

Reg. No. : | | | | | | | | | | | | |

Question Paper Code : 50410

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2017
Sixth Semester
Electronics and Communication Engineering
EC 6001 – MEDICAL ELECTRONICS
(Regulations 2013)

Time : Three Hours Maximum : 100 Marks

Answer ALL questions

PART – A **(10×2=20 Marks)**

1. Define Lead. Name the types of leads used for ECG.
2. Define action potential.
3. What is meant by total lung capacity ?
4. Give the merits and demerits of electromagnetic blood flow meter.
5. Compare Haemodialysis and peritoneal dialysis.
6. What is meant by fibrillation ? And give its type.
7. Define micro and macro shock.
8. List the applications of diathermy.
9. State the principle of Thermography.
10. List out the properties of LASER.

PART – B **(5×16=80 Marks)**

11. a) Discuss the different types of surface electrodes and its applications. **(16)**

(OR)

b) i) With circuit diagram explain the instrumentation amplifier. **(8)**

ii) Give the origin of brain waves and describe the 10-20 electrode system used in EEG. **(8)**

12. a) Explain the principle of following :

i) Auto analyzer (8)

ii) PO_2 measurement (8)

(OR)

b) i) Explain auscultatory blood pressure measurement and write its advantages and disadvantages. (8)

ii) Write the principle of coulter counter and with block diagram explain multi parameter coulter counter. (8)

13. a) i) Explain working principle of demand pacemaker with a diagram. (8)

ii) Explain the DC defibrillator. (8)

(OR)

b) Explain the heart lung machine with neat block diagram and discuss about the different types of oxygenators. (16)

14. a) i) Draw the block diagram of short wave diathermy unit and explain it. (8)

ii) Explain the working of a biotelemetry system with sub-carrier. (8)

(OR)

b) Define Leakage current. Explain the impact of leakage in cardiac patient and discuss about the prevention methods. (16)

15. a) i) Discuss the various applications of lasers in different fields of medicine. (8)

ii) Discuss the benefits and limitations of telemedicine. (8)

(OR)

b) With neat sketch explain the following :

i) Thermograph (8)

ii) Endoscopy unit. (8)

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Reg. No. : | | | | | | | | | | | | |

Question Paper Code : 20384

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2018.

Sixth Semester

Electronics and Communication Engineering

EC 6001 — MEDICAL ELECTRONICS

(Regulations 2013)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Differentiate micropipette and metal microelectrode.

2. Define relative refractory period.

3. Write the principle of colorimeter.

4. State the principle behind Rheographic method of blood pressure measuring technique.

5. Write down the advantages of DC defibrillator over AC defibrillator.

6. What is dialyasate? Mention its composition.

7. State the difference between micro and macro shock.

8. Mention the features of Ultrasonic type diathermy.

9. List the applications of cryogenic technique.

10. Write the principle of Liquid Crystal Thermograph.

PART B — (5 × 13 = 65 marks)

11. (a) (i) With a neat block diagram, explain the working principle of ECG recorder. (8)

(ii) Give an account on surface electrode and state its application. (5)

Or

(b) (i) Describe in detail about 10-20 electrode system. (8)

(ii) Explain the working principle of isolation amplifier. (5)

12. (a) Explain in detail about thermo dilution and dye dilution of cardiac output measurement technique. (13)

Or

(b) Describe in detail about the working principle of electromagnetic type blood flow meter. (13)

13. (a) With a neat block diagram explain the principle of operation of a hemo dialyzer machine. (13)

Or

(b) Draw the block diagram of synchronized DC defibrillator and explain its working principle. (13)

14. (a) Explain the working principle of surgical diathermy unit with a neat block diagram. (13)

Or

(b) (i) Describe the working of biotelemetry system. (8)

(ii) State the influence of leakage current in cardiac patients and explain in detail about the preventive method. (5)

15. (a) Describe the working principle and image acquisition technique using thermograph. (13)

Or

(b) Give a detailed description of about fiber optic endoscopy system. (13)

PART C — (1 × 15 = 15 marks)

16. (a) Explain the working of Heart Lung Machine (HLM) and state its application. Justify the scenarios where HLM can be used.

Or

(b) Design a suitable amplifier that can be used in the front end of an ECG machine. Justify your by specifying the features of the selected amplifier.