UNIT IV

PHYSICAL MEDICINE AND BIOTELEMETRY

Diathermies- Shortwave, ultrasonic and microwave type and their applications, Surgical Diathermy , Telemetry principles, frequency selection, biotelemetry, radiopill, electrical safety

4.1DIATHERMY

Operation theatre equipment are very useful both diagnostically and therapeutically. They are mainly useful for monitoring and treatment purpose. During operation, the patient's condition is followed carefully by measuring variable like blood flow velocity, cardiac output, blood pressure, P^H value. Diathermy is the treatment process by which cutting, coagulation of tissues are obtained.The types of Diathermy are

(i)Short wave diathermy
(ii)microwave diathermy
(iii)Ultrasonic diathermy
(iv)surgical diathermy

4.1.1 Short – Wave Diathermy

The heating of tissues is carried out at a high frequency of 27.12 MHz and a wavelength of 11 m. By using currents with very high frequencies, the motor nerves are not stimulated and there is no contraction of muscles. Thus there is no discomfort to the patient.

The output of R.F oscillator is applied to the pair of patient electrodes. The R.F energy heats the tissues and promotes the heating of injured tissues and inflammations. The power delivered is about 500w. The electrodes or pads are not directly contact with skin. Usually layers of towel are interposed between the metal and surface of body. The pads are forming capacitor plates and the body tissues between the pads act as dielectric. Thus the whole arrangement forms a capacitor. When R.F current applied to the pads, the dielectric loss of the capacitor produces heat in the intervening tissues. This technique is called condenser or capacitor method. In inductive method, a flexible cable is coiled around the arm. When R.F

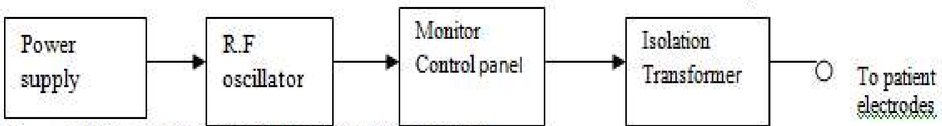


Fig Block diagram of a short wave diathermy unit

current is passed through the cable. Deep heating in the tissue results from electrostatic field set up between its ends and heating in the superficial tissues is obtained by eddy currents set up by magnetic field around the cable

Instead of continuous R.F wares, R.F pulses of 65 µs with on interval between pulses of 1600 µs are also used. This is called Dia-pulse shortwave diathermy. The rate of pulsation is from 80 to 600 pulses/ sec with peak power of 293 to 975 w. By this methods the excess tissue fluid associated with Cellular damage is reduced, Heating rate is enhanced, No danger of burns, the depth of penetration is correctly adjusted.

4.1.2 Microwave Diathermy

The frequency used is 2450MHz and wavelength of 12.25 cm. Heating of tissues is produced due to adsorption of microwave energy.

Better therapeutic results are obtained by using microwave diathermy than short wave diathermy. There is no pad shaped electrode. Microwaves are transmitted into the body directly.

Magnetrons are used to produce microwaves. A delay of 3-4 min is required for the warming of magnetron.

Arrangement is made such that a lamp lights up after 4 min indicating the magnetron is ready to its output. Proper cooling of magnetron is provided.

The interference suppression filters by pass the high frequency current pick up in the circuit.

4.1.3 Ultrasonic diathermy

Ultrasonic therapy is used where short wave treatment is failed and where localization of heat effect is desired. It is very helpful to cure the diseases of peripheral nervous system. The heating effect is produced due to the absorption of ultrasonic energy by the tissues. The effect of ultrasonic on the tissues is a high speed vibration of micromassage. Micromassage is used in the treatment of soft tissue lesions. Ultrasonic massage is better because of greater depth of massage can be obtained without any pain to the patient.

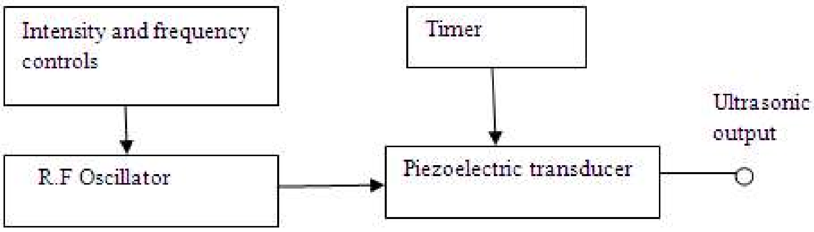


Fig4.1.3: Block diagram of an Ultrasonic diathermy unit

R.F oscillator produces a high frequency alternating current which excites the piezo electric transducer. The ultrasonic waves can be applied in contained or pulsed mode.

In case of pulsed mode, micro massage is obtained effectively without any thermal effect. In front of crystal, there is a metal face plate which is made to vibrate by the oscillations of crystal.

Ultrasonic wave are emitted from this plate. The amount of ultrasonic energy absorbed by the tissues is depending upon the frequency of ultrasonic waves. The frequency ranges from 800 KHz to 1 MHz and the output power can be varied from 0 to 3 w/cm^2.

The treatment timer is an electrically operated contact which can be set from 1 to 15 min. It switches off the output power often the present time. He transducer probe is in direct contact with the body through an electrode gel.

In case of large areas to be treated, the probe is moved up and down to obtain uniform distribution of ultrasonic energy.

If there is a wound, the treatment is carried out in a warm water both to avoid the mechanical contact with the already injured tissues.

4.1.4 Surgical Diathermy

When high frequency current of 1-3 MHz is applied, heating of tissues takes place. The evolving steam bubbles in the tissues continuously rupture the tissues and by that way cutting action is obtained.

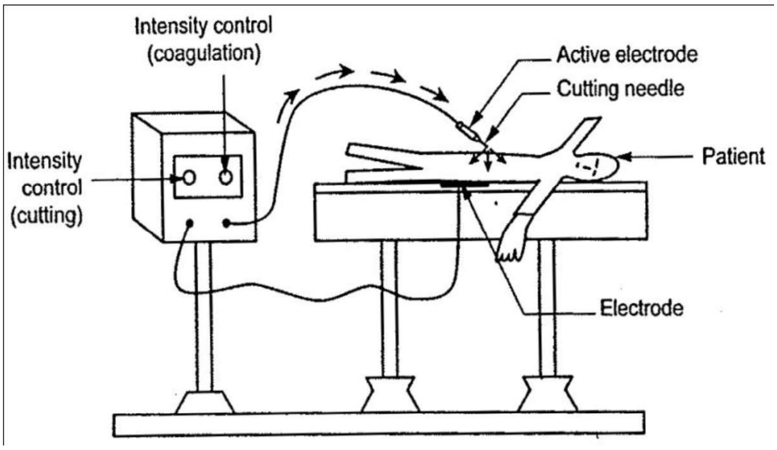


fig4.1.2 Surgical Diathermy

During the passage of high frequency current through the tissue, tissue is heated locally. So that the tissue is melted instantaneously and sealing of the blood vessels is taking place. Thus the coagulation of tissues is taking place

The various electrosurgery techniques using diathermy unit are

1. Fulguration

When the electrode is held near the tissue without touching it and due to the passage of electric are, destruction of superficial tissues take place.

It is related to the localized surface level destruction of tissues. Needle or Ball electrodes are used.

2. Desiccation

The needle point electrodes are stuck into tissue, while passing electric current a local increase in heat creates drying of tissues. This is called desiccation which produces dehydration in tissues.

3. Electrotomy

When the electrode is kept above the skin, an electrical are is sent. The developed heat produces a wedge shaped cutting of tissue on surface. Continuous R.F current is used for cutting.

4. Coagulation

When the electrode is kept above the skin, high frequency current is sent through the tissues in the form of bursts and heating it locally so that it coagulates from inside. The concurrent use of continuous R.F current for cutting and a R.F wave burst for coagulation is called Hemostasis mode.

5. Blending

When the electrode is kept above the skin, the separated tissues can be combined together by an electric arc. This is called blending.

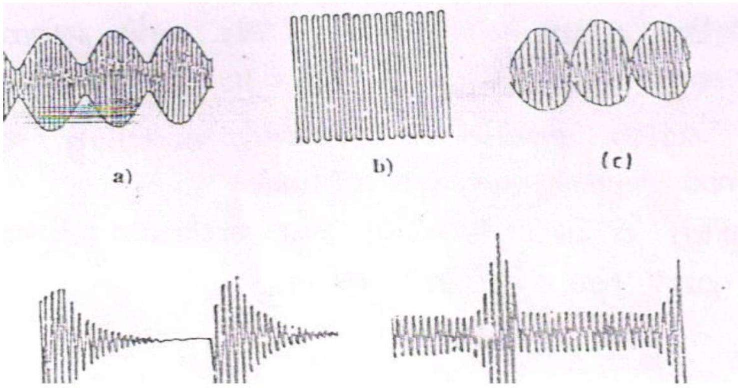


Fig.: Different types of waveforms used in electrosurgical diathermy unit

Special Features

(i) To secure safety for the patient or operator, the output unit is isolated and insulated from the low frequency primary and secondary voltages.

(ii) The bipolar electrodes are used such that the active electrode is mounted in an insulated handle and in different electrode is placed at the back of patient in the form of plate.

(iii) The output of the unit may be earth referenced or isolated. The isolated output dose not produce any fibrillation and any serious burns.

(iv) The active electrodes for cutting are in the form of needle electrode and the active electrode for coagulation are in the form of a ball or plate.

(v) These are circuit integrity monitors like patient circuit continuity monitor, alternate path current monitors etc.

(vi) The frequency of operation is from 20 KHz to 1 MHz. The output power for cutting is about 400 w and for coagulation is 150 w.

4.2 Electro Surgical Diathermey

Logic board is the main part of the unit which produces the necessary waveforms for cutting, coagulation and hemostasis mode of operation. An astable multivibrator generates 500 KHz square pulses.

The outputs divided into a number of frequencies using binary counters. These frequencies are used as system timing signals. A frequencies of 250 KHz provides a split phase signal to drive output stage on power output board.

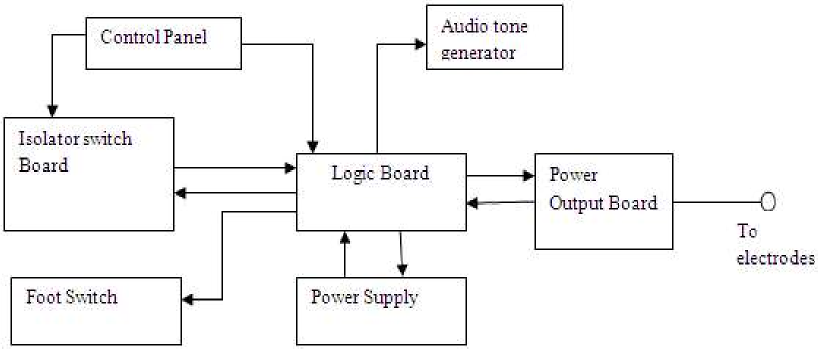


Fig4.2.:Block diagram of electrosurgical diathermy unit

A frequency of 50 KHz provides a gating signal for making coagulating output. The frequency of 250 KHz is used for cutting. To indicate each mode of operation, diathermy unit is provided with an audio tone generator. When coagulation output is delivered, 1 KHz audio signal is heard. Similarly 500 Hz for cutting and 250 Hz for hemostasis. The isolator switch provides an isolated switching control between the active hand switch and rest of unit. The foot switch is used to avoid any explosion formed by the an aesthesia gases near electrical contacts.

4.3 BIO TELEMETRY

4.3.1 Introduction:

Bio telemetry is electrical technique for conveying biological information from a living organism to a location where this information can be observed or recorded. Thus it refers to the communication between a living system and an observer. Today bio telemetry is extended for monitoring Patients in a hospital from a remote location for monitoring Astronauts in space patients who are on the job or home carrying implanted pacemaker. Athletes running a race.

4.3.2 Elements of Bio-telemetry:

The transducer converts the biological signal into electrical signal. The signal conditioner amplifies and modifies the signal for effective transmission. The transmission link connects the signal input blocks to the read out device by wire or wireless mean.

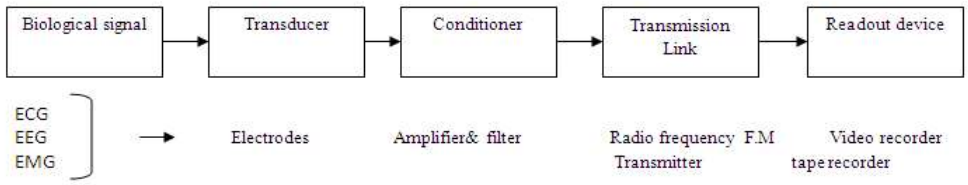


Fig 4.3.2 : Block diagram of Bio-telemetry system

4.3.3 Design of a Bio-telemetry system:

1. The telemetry system should be selected to transmit the bioelectric signals with maximum fidelity and simplicity.
2. There would not be any constraint for living system and any interference with the living system.
3. The size and weight of the telemetry system should be small.
4. It should have more stability and reliability.
5. The power consumption should be very small.
6. For wire transmission shielding of cable is a must to reduce noise level.

4.3.4 Radio telemetry system:

Most biotelemetry systems are involved with radio transmission and reception of biosignals. There are single channel and multichannel

4.3.4.1 Single channel telemetry system:

A miniature battery operated radio transmitter is connected to the electrodes of the patients. This transmitter broadcasts the biopotential to a remotely located receiver. The receiver detects the radio signals and recovers the signals for further processing. The receiving system can even be located in a room separate from the patients.

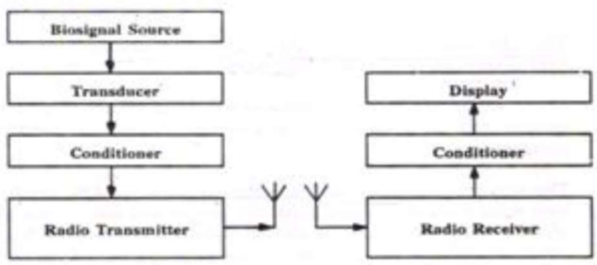


Fig4.3.4.1 : Block diagram of a typical single channel telemetry system

The only risk of electric shock to the patient is due to the battery powered transmitter. Since it is kept low there is negligible risk to the patient. The radio frequency used in this system varies from a few 100khz to about 300mhz. Beyond this frequency range Attenuation becomes excessive. At higher frequencies transmitter should be small and the man made noise should be small. Amplitude modulation is not adopted between the transmitter and receiver because the signal amplitude will be varied and thus introduces serious error. Thus we must adopt either frequency modulation or pulse modulation techniques to transmit the bio signals.

Transmission of bioelectrical variables:

In a single channel telemetry system the measurements are made under any of the two categories.

1.Active Measurements: Here the bioelectric variables like ECG,EMG,EEG are directly measured without any excitation voltage.

2.Active Measurements:Here the bioelectric variables like blood pressure, temperature, blood flow etc are measured indirectly using transducer and excitation voltage.

4.3.4.2 Multi channel telemetry system:

Most bio medical experiments need simultaneous recordings of several signals. Each signal requires a telemetry channel when the number of channels is more simultaneous operation of several single channel unit is difficult. Thus multiple channel (multiplex) telemetry system is adopted.

There are two types

1. Frequency division multiplex
2. Time division multiplex

(a) Frequency division multiplex system:

Each signal is frequency modulated on a subcarrier frequency. Then these modulated subcarrier frequencies are combined to modulate the main R.F carrier. At the receiver side the modulated subcarriers will be separated by the proper band pass filters after the first discrimination. The individual signals are recovered from these modulated subcarriers by the second set of discriminators. The frequency of the subcarriers has to be carefully selected to avoid interference. The low pass filters are used to extract the signals without any noise.

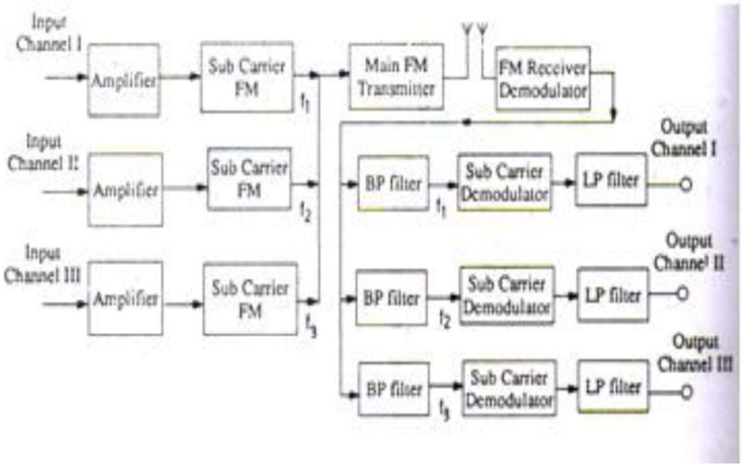


Fig4.3.4.2 (a) : Frequency division multiplex system

(b) Time division multiplex system:

Since most biomedical signals have low frequency bandwidth requirements we can use time division multiplex system by the time sharing scheme.

The transmission channel is connected to each signal channel input for a short time to sample and transmit that signal.

Then the transmitter is switched to next signal channel in a definite sequence. When all the channels have been scanned once a cycle is completed and the next cycle will start.

The operation is repeated again. At the receiver end the process is reversed. If the number of scanning cycles per second is large and if the transmitter and receiver are synchronized the signal in each channel at the receiver side can be recovered without any distortion.

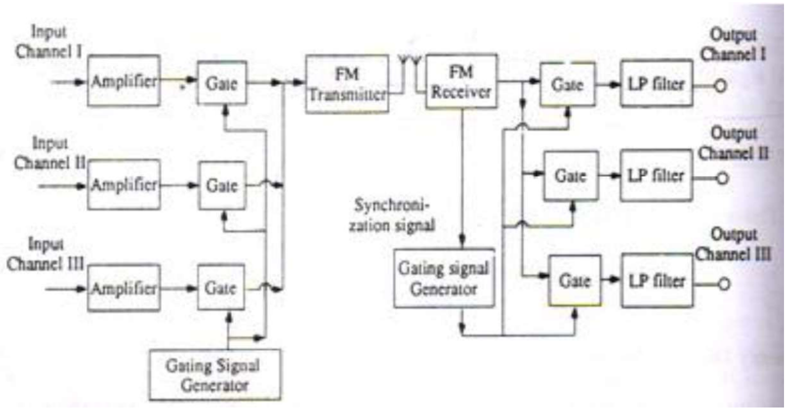


Fig4.3.4.2 (b) : Time division multiplex system

Conditions:

The scanning frequency fn should be at least greater than twice the maximum signal frequency fs.

(ie) fn>2fsmax

If Tn=1/fn=scanning period and tn is the sampling time of each channel than the maximum no. of channels n=Tn/Tn. Practically the no. of channels is smaller than 'n' to avoid interference between channels.

4.3.5 Telemetry Circuits:

a)Tunnel diode FM transmitter

Tunnel diodes are active devices (TD,BD) and this circuit has higher fidelity and sensitivity. Total weight is about 1.44gm with battery. Size is so small(0.8x0.22 cm^2).

The circuit details are :Radio frequency :100 to 250 MHz

Frequency response : 0.01Hz to 20 KHz

Input impedence : 300KΩ to MΩ

Temperature stability of carrier frequency :0.05% /^{0}C

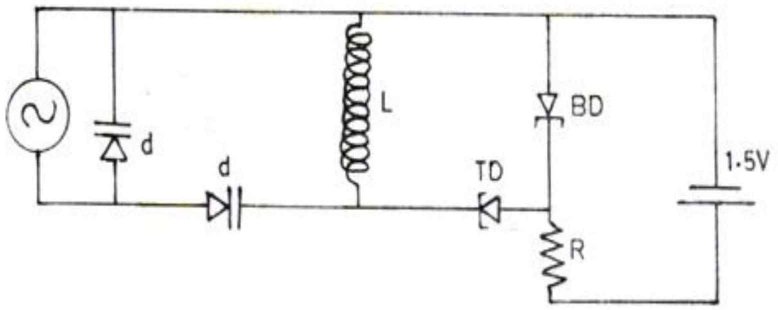


Fig4.3.5 (a) : Single channel FM transmitter

Varactor diodes 'd' which are voltage sensitive semiconductor capacitors are used for frequency modulation .The signal is transmitted through the inductor 'L'.

Advantages:

All the signals can be transmitted to a receiver in a normal hospital environment.
No shielded room is needed.
Interference is greatly reduced

b) Hartley type F.M transmitter:

For the transmission of ECG,EEG and EMG

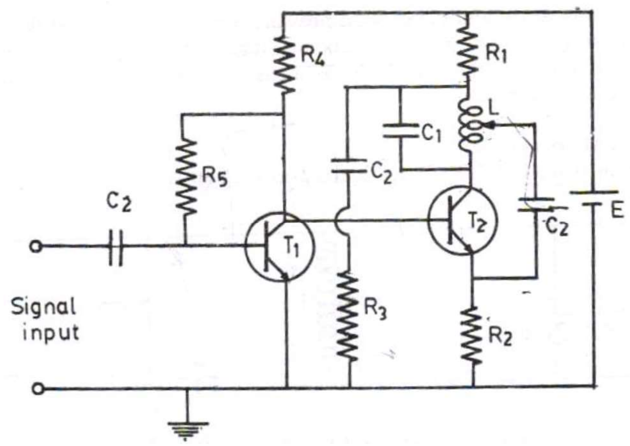


Fig4.3.5 (b) : Hartley type F.M transmitter

In this circuit C1 and L form the tank circuit components of Hartley oscillator.

C_2-coupling capacitor
T1-Driver amplifier transistor
T2-oscillator transistor

The capacitance between the emitter and base of a transistor is voltage sensitive is used to frequency modulate the carrier.

The amplitude of input signal may vary from 10µv to several v. The transmission range is from few meters to 30m at a power consumption level of mw. Bandwidth of the signals is from few 100Hz to 1000Hz

c)Pulsed Hartley oscillator:

To measure temperature a thermistor is placed in the place of R1. To measure pressure the pressure changes should be given to more the core 'M'.

To measure pH or any voltage suitable electrodes are connected across the voltage input XX'. The transmitter is modulated by varying the rate of pluses of radio frequency oscillations.

The transducers and conditioner are integrated in to components of the oscillator-transmitter. Continuous wave operation can be obtained by reducing then value of R1.

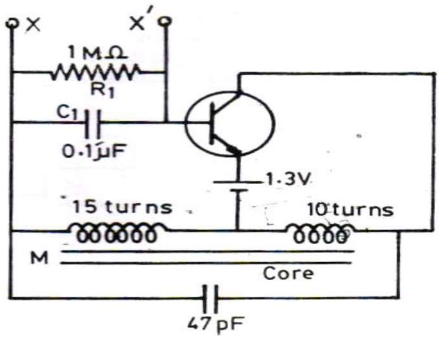


Fig4.3.5 (c) : Physiological parameters telemetering transmitter

Advantages:

The circuit is so simple

Low power consumption from 5µW to 10µW

Limitations:

In pulse mode operation large error can be produced by power supply voltage variations.

Interference can be generated over wide frequency band because of self blocking pulsed carrier mode operation.

d) Radio telemetry with a sub-carrier:

When the relative position of transmitter changes the carrier frequency and amplitude will change. This is due to the loading change of the carrier frequency resonant circuit.

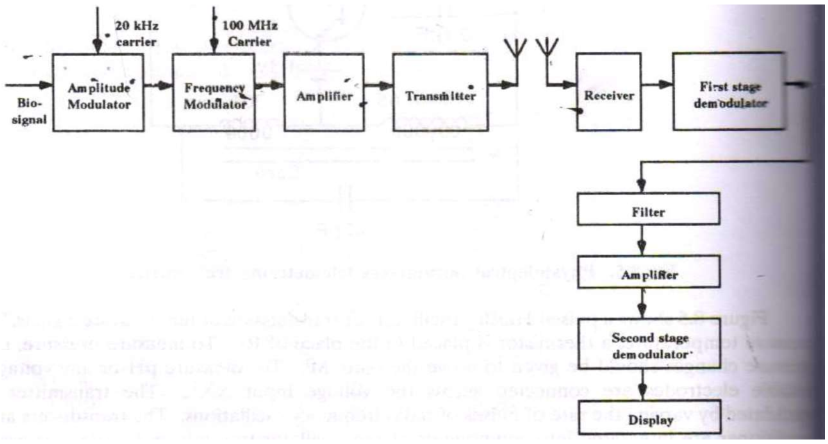


Fig4.3.5 (d) : Biotelemetry system with subcarrier

If the signal has frequency different from loading effect they can be separated by filters. Otherwise the real signal will be distorted by the loading effect. To avoid this loading effect subcarrier system is needed.

The signal is modulated on a subcarrier to convert the signal frequency to the neighborhood of subcarrier frequency. Then the R.F carrier is modulated by this subcarrier carrying the signal. At the receiver end the receiver detects the R.F and recovers the subcarrier carrying the signal. Since the subcarrier frequency is different from noise interference and loading effect it can be separated by filters.

Demodulation is needed to convert the signal from the modulated subcarrier back to its real frequency and amplitude. This technique is used for recording biosignals for several weeks.

4.3.6 Problems in implant telemetry:

For long term telemetry implant telemetry is more useful one. The whole electronic circuit is fully packed as a capsule and then implanted deep in the body to be closer to the signal source and to avoid mechanical difficulties of surface mounted units.

The size and weight limitations are much more serious and the reliability requirement is more critical.

Body reaction: Size ,weight ,surface condition and shape of the implant system will have effects on body reaction.

Protection of electronic circuit: The coating materials of electronic circuits to protect them from body fluid are silicon rubber, epoxy, plastics, paraffin, glass and metal.

Power supply: Two special types of power supplies are used

(i) Environmental power supply

(ii) Microwatt power supply

4.3.7 Uses of bio-telemetry:

1.Biotelemetry helps us to record the biosignals over long periods and while the patient is engaged in his normal activities.

2.The medical attendants can easily diagonise the nature of disease by seeing the telemetered signals without attending the patient's room.

3.Patient is in his room without any mechanical disturbance during recording by means of biotelemetry.

4.To study the treatment effect biotelemetry is the essential one.

5.For recording on animals ,particularly for research the biotelemetry is greatly used.

6.For monitoring the persons who are in action the biotelemetry is an ideal one.

4.4 RADIO-PILL:

Radio-pill is used in biotelemetry. It is the transmission of biological signal. In Radio-pill a transducer converts the signal to be measured in to an electrical form which can be amplified digitised so that it is suitable for transmission to other parts of system.

The methods of communication is usually radio means and hence called radio telementry. Other frequent uses are in monitoring patients who have certain conditions which put them at risk.

In these cases it may be necessary to implant the transducer transmitter and power supply in a single assembly is called Radio pill.

The Radio pill is either swallowed or introduced surgically. The radio transmitter is essentially an electronic circuit which produces an alternating current (oscillator). This generates a radio wave which is detected in a corresponding receiver.

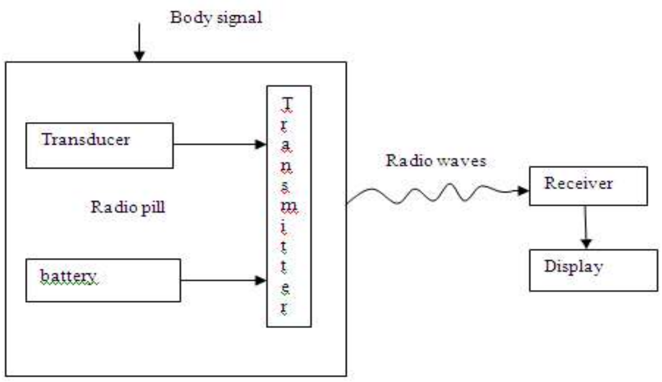


Fig 4.4 : Block diagram of Radio pill

The radio pill is capable of measuring various parameters.

With the help of radio pill type devices, it is possible for use to measure or sense temperature, pH, enzyme activity, and oxygen tension values.

These measurements can be made in associated with transducers. Pressure can be sensed by using variable inductance, temperature can be measured by using temperature-sensitive transducer.

4.5 TELEMETRY PRINCIPLES:

Design considerations for a telemetry system

1. Simplicity of the telemetry system
2. Transmission should be with maximum fidelity
3. Telemetry components should be less weight and size
4. High reliability and stability is must
5. Power consumption should be small
6. Shielding of the cable is a must in wire based transmission
7.

Telemetry system:

Telemetry is defined as the process by which the information regarding the quantity being measured transmitted to a remote location for application like data processing ,recording or displaying.

In other words telemetry means measuring at a distance. Therefore it becomes essential to transmit data through some form of communication channels.

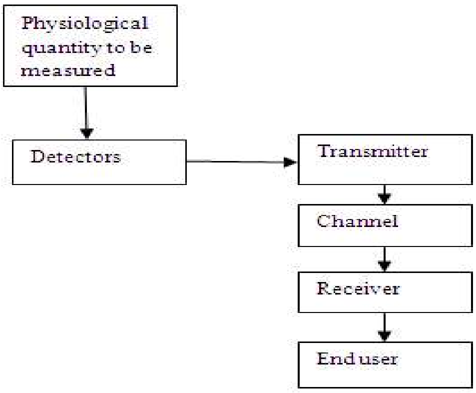


Fig4.5: Telemetry system

Methods of classification of telemetry system:

a. On the basis of the characteristics of electric signal such as voltage current position ,frequency and pulse
b. Based on form of data transmitted –analog and digital
c. Based on transmission of distance –short distance type or long distance type
d. Based on whether user has control over transmission channel or not.

The physiological quantity to be measured by a suitable detector and given to the transmitter. The electrical telemetry system is broadly classified as DC systems and AC systems.

DC telemetry system:

The signal is transmitted through a telemetry or communication channel which uses direct transmission via cables in order to convey the desired information . This is known as land line telemetry.

AC telemetry system:

It is used both for land line and radio frequency air borne telemetry techniques. Electronics means are used for sensors that provide an AC output or voltage to frequency converter. The data is available in the form of current or voltage which is generally weak . Hence It is modulated with carrier signals for transmission. These modulated signals are demodulated at the receiving end which means recovering the original signal from carrier wave. Basically there are three types of modulation

Amplitude modulation:

In this type of modulation the amplitude of the carrier is varied in accordance with the signal to be transmitted.

Frequency modulation:

In this type of modulation the instantaneous frequency of the carrier is varied in accordance with the amplitude of the modulating signal.

Phase modulation:

Here phase angle is varied in accordance to be transmitted signal.

Communication channels(or) Transmission media:

The most widely used communication channels are cables and electro magnetic radiation radio links. Optical ,ultrasonic and magnetic induction data links are also used for many applications. Land line telemetry utilizes cables or wires to transmit data. When data is to be transmitted for more than 1km radio links are preferred. For frequency above 30MHz microwave links are used. For short range transmission upto 50m frequency modulation used.

4.6 FREQUENCY SELECTION:

The radio frequencies normally used for medical telemetry puposes are of the order of 37, 102, 153, 159, 220and 450 MHz. The transmitter is typically of 50mW at 50Ω., which can give a transmittion range of about 1.5km . The low frequency band of 174-216 MHz coincides with the VHF television broadcast band .

Therefore the output of the telemetry transmitter must be limited to avoid interference with TV sets. Operation of telemetry units in this band does not normally require any licence.In higher frequency band of 450-470 MHz greater transmitter power is allowed , Radiowaves can travel through most nonconducting material such as air , wood, and plaster.

The transmission may be lost or poor quality when a patient with a telemetry transmitter moves in an environment with a concrete wall. One problem that is sometimes present in the telemetry system is the cross talk or interference between telemetry channels.

It can be minimized by the careful selection or transmitter frequency, By the use of suitable antenna system and by the equipment design.

The range of any radio system is primarily determined by transmitter output power and frequency.

However in medical telemetry system factors such as receiver and antenna design may make the power and frequency characteristics less significant.

The use of higher powered transmitter than is required for adequate is referable as it may eliminate or reduce some noise effects due to interference from other sources.

4.7 ELECTRICAL SAFETY IN MEDICAL EQUIPMENTS

For a biomedical engineer, electrical safety and patient shock hazard with the se of biomedical equipment have become a important problem.

Devices should be handled with extreme care to avoid electrical shock, excessive radiation, fire, explosion & other hazards. Patient and hospital equipment user are especially susceptible o shock because they are in physical contact with hardware.

The physiological effects or shock range from discomfort to injury to death, if the heart or respiratory systems are affected. An electrical shock is an unwanted physiological response to current.

Electrical shock may cause an unwanted cellular depolarization, cell vaporization and tissue injury. At commercial frequencies, the body acts as a volume conductor. The physiological effect due to the passage of current are listed below.

Table Physiological effect of current at50 Hz

Type of current	Current range (mA)	Physiological effect
Threshold	1-5	Tingling sensation
Pain	5-8	Intense or painful sensation
Let-go	8-20	Threshold of involuntary muscle contraction
Paralysis	>20	Respiratory paralysis and painful
Fibrillation	80-1000	Ventricular and heart fibrillation
Defibrillation	1000-10,000	Sustained myocardial contraction temporary respiratory paralysis and possible tissue burns

Let go current is the minimum current to produce muscular contraction. Let-go current for men is about is mA and for women is about 10.5 mA. Between 5 Hz to 200 Hz the value of let-go current is so low. Above 200 Hz, let-go current is directly proportional to the logarithm of frequency. Let-go current also depends on weight and time of passage of current through the body.

4.7.1Microshock and Macroshock

Macroshock

A physiological response to a current applied to the surface of the body that produces unwanted stimulation like muscle contractions or tissue injury is called macroshock. All hospital patients and medical attendants are exposed to macroshock from defective electric devices and biomedical equipment.

Microshock

A physiological response to a current applied to the surface of heart that results in unwanted stimulation like muscle contraction or tissue injury is called microshock. Microshock is caused when current in excess of 10 µA flow through an insulated catheter to the heart. Catheter may be an insulated, conductive fluid filled tube or a solid wire pacemaker cable.

4.7.2 Electrical Accidents in Hospitals.

One of the main hazards connected with the use of medical equipment is electrical shock.

A macroshock may cause secondary injury to a limb of technician repairing equipment, such as acts on hand as the person pulls away from equipment. Microshock can cause a heart fibrillation and can result in a patient's death.

Shock is defined in terms of current because the voltage that produce the current are highly variable. The variance in voltage is caused by wide variation in skin resistance among individuals. The skin resistance may vary from 93kΩ to 20 vΩ.

Table skin Resistance at 50 Hz

Condition	Skin resistance per Square Centimeter of Electrode
Dry Skin	93.0k Ω
Electrode gel on skin	10.8k Ω
Penetrated skin	200.0Ω

All electrical and electronic devices in the hospitals are sources of potentially harmful current. The electrical power has consists of three wires a hot wires 'H', a neutral wire 'N' and a ground wire 'G'.

The neutral wire carries the return current from equipment loads and carries the same current as the hot lead. The G wire is connected to external parts of equipment to bleed away any leakage and to prevent from acquiring a high voltage in case of a short or fault in the circuit.

4.7.3 Microshock hazards

Many devices have a metal chassis and cabinet that can be touched by the medical attendants and patients. If they are not ground then an insulation failure or short circuit result and leads to macroshock or microshock.

a) Leakage currents

Most of the accidents occur due to improper grounding and leakage currents, The leakage currents is an extraneous current flowing along a path.

It could be due to resistive inductive or capacitive couplings with the mains or some electronic equipment. A patient in an electrically operated bed has a pacemaker with a bipolar catheter going to right ventricle of heart.

The pacemaker case is connected to grounded of power core. The three wire power cord is connected to a two wire extension cord. The bed frame is properly grounded to power system. The patient's left hand is resting on bed frame.

The leakage current is passed from the pacemaker through the catheter into the heart and then to ground via bed frame. The heart is under ventricular fibrillation. This dangerous accident arises because of open ground of the pacemaker by using a two wire extension cord.

The leakage current flow is due to

Undergrounded equipment

Broken ground wire

Unequal ground potential

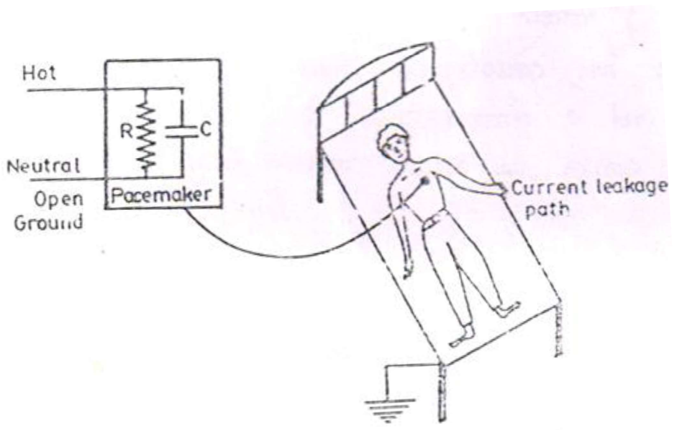


Fig. . Microshock due to leakage current

Even if the three wire (H,N,G) power cord is used with the broken ground wire connection, then the above accident could be occurred. For example the doctor it holding a pacemaker wire by his one hand touching the electrical bed frame by his other hand as shown in fig.

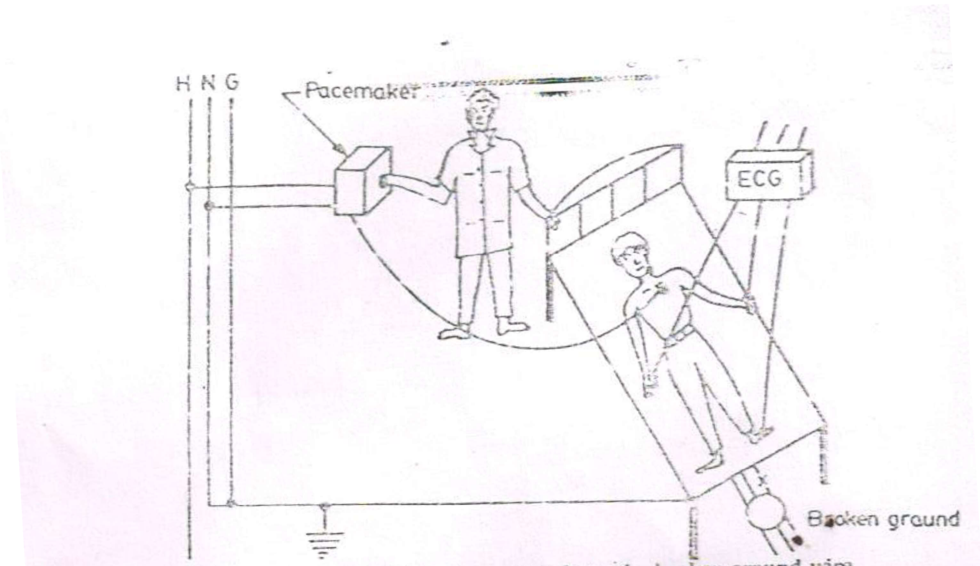


Fig. Microshock for the patient from the broken ground wire

Broken ground connection on the electric bed allows a voltage to exist on the frame due to capacitive coupling between bed frame and power line.

The pacemaker wire is going into the heart of patient. The heart activity is monitored by an ECG recorded.

Hence a leakage current flows from the motor of bed frame to the medical attendanere's hand and to the patient's heart through the catheter and then to the ground of ECG unit.

b) Static Electricity

Static electricity may be dangerous to people and sensitive equipment having integrated circuit.

Sparks from static electricity could ignite flammable gases causing an explosion. Shocks from static electricity could cause cardiac arrest if applied to a pacing catheter. Floor carpeting is very common source of static electricity charge buildup.

. A vacuum cleaner is plugged into a wall power outlet. The frame of vacuum cleaner is connected to ground.

The motor in the cleaner due to dust collection and moister may provide a leakage current path from line to outer casing.

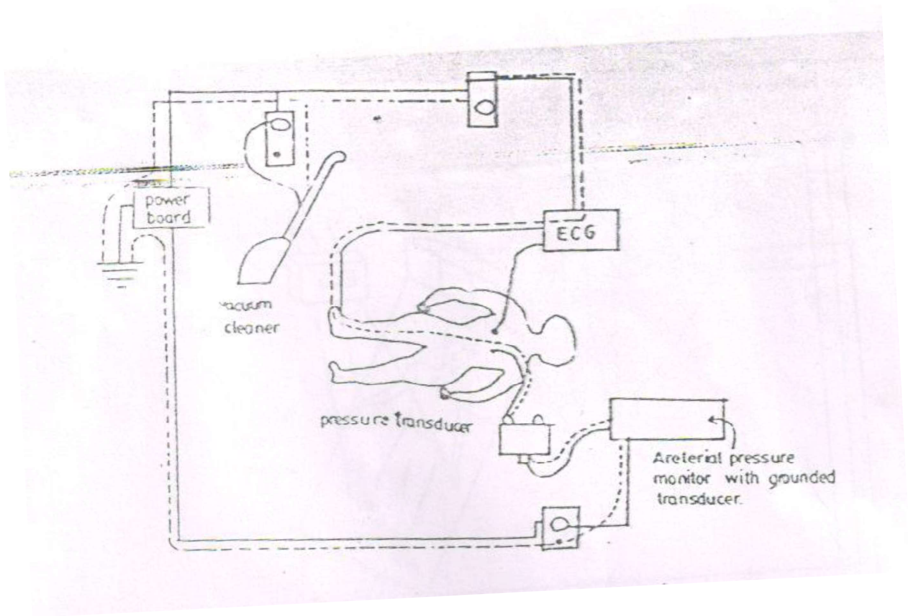


Fig : static electricity

If a fault current of 1 A flows from the vacuum cleaner casing to ground of power board then a voltage of 80 mV is developed. The microshock arises due to static electricity due to dust collection in the motor of vacuum cleaner.

c) Interruption of power

Interruption of electrical power to life support equipment can also be hazardous. If a delay occurs before emergency power is brought into operation, the failure of a respirator monitor, defibrillator, pacemaker can be fatal.

Electrical service to life support equipment should be as nearly as possible and uninterruptable. Emergency power generation equipment within the hospital is necessary to provide limited power in the case power failure.

4.7.4 Macroshock hazards

Macroshock occurs more often with two-wire system than with three-wire system. If the patient touches H and N wires simultaneously with two limbs, then the currents are flowing directly through vital organs of circulation and respiration. N wires are internally grounded, hence touching H and G wires can produce macroshock.

Fig illustrates additional hazardous situations that result from faults which occur in the equipment.

In part (a), H lead shorts to patient lead P. Thus a macroshock result if the patient touches ground or chassis.

In part (b), H & N are reversed because the two wire plug has been reversed. A grounded patient is shocked upon touching the chassis.

In part (c), H wire shocked to chassis causing a shock as the patient touches either neutral or ground and chassis.

In part (d), neutral wire shocks to equipment leading to a shock situation of H to chassis or H to ground

The primary definse against the hazards of a two-wire plug is to add a third ground wire as in 3-pin plug. This wire is connected to chassis of equipment and ensures that it will not rise to a high voltage. Another method is to double insulate the chassis. (i.e) To place a layer of insulation between circuit board chassis and equipment exposed to user.

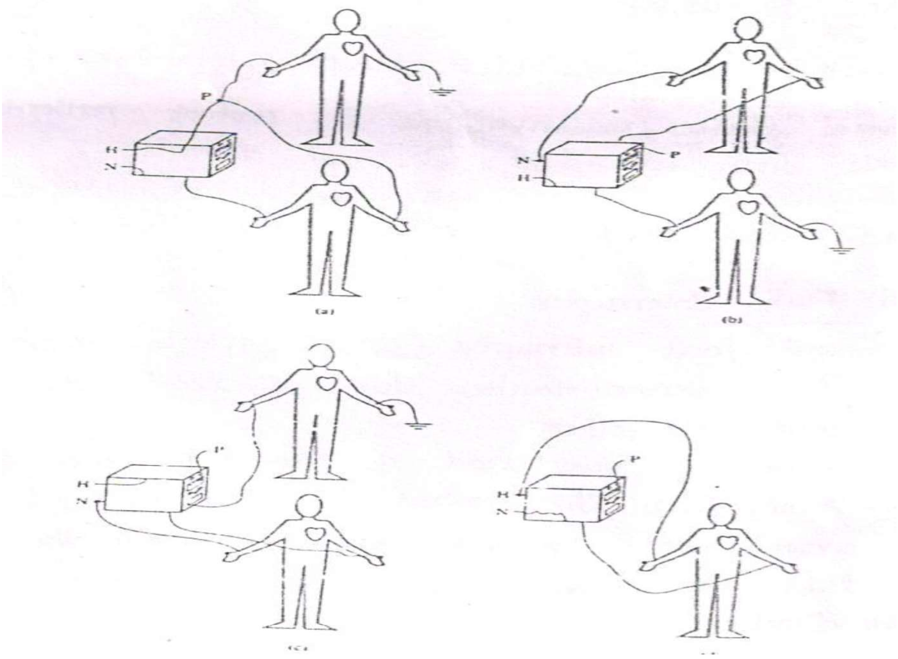


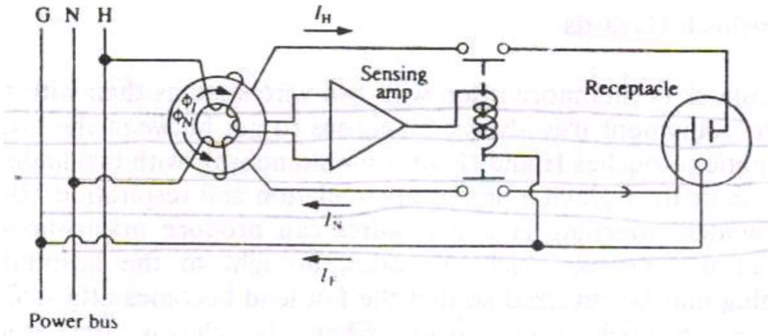
Fig : Macroshock situations in the case of two wire units

4.7.5 DEVICE TO PROTECT AGAINST ELECTRICAL HAZARDS

Several devices are available to protect patient and health care workers from hazardous electrical currents. By protecting the devices against high-voltage macroshock hazards that minimize the probability that a micro shock will occur.

4.7.5.1 Ground Fault Interrupter

A ground fault interrupter (GFI) protects against a shock that occurs if a person touches the hot lead with one hand and ground with the other. GRI opens the power lead if the hot lead current differs by approximate 2mA from the neutral lead current. GFI consists of a magnetic coil on which the hot lead and neutral lead are wound with the same number of turns but in opposite directions.



When the system is normal $I_N = I_H$

The magnet flux φ in the coil cancels.

Sensing coil does not have a voltage induced in it

When the hot lead faults or is touched by a person, the fault current. If is shunted to ground.

$$I_N = I_H - I_F$$

I is not equal to I

The corresponding fluxes in the coil are unequal and a net flux exists in the coil which induces a voltage into sensing amplifier. If I_F exceed 2 mA for 0.2 sec, the relay opens the line and prevents a macroshock from injuring the person and preceding damage to equipment. GFT can be mounted in the power receptacte. It is required in wet areas.

4.7.5.2 Isolation Transformer

Isolation transformer provides a second means of protecting against an H lead to G-lead macroshock. It prevents sparks when H lead touches ground, particularly protection in an explosive or flammable environment.

Fig (a) shows that a fault such as a short circuit from either secondary lead of transformer to ground will carry no current. A secondary lead to ground spark or shock is prevented. When the isolation transformer is in use and equipment is plugged into the secondary, stray capacitance and input impedance of the hardware tend to make a conductive path to ground.

This reduces the isolation by completing the circuit from either secondary lead to ground and then to other secondary level. If a fault should now occur on the secondary, a hazardous current could flow.

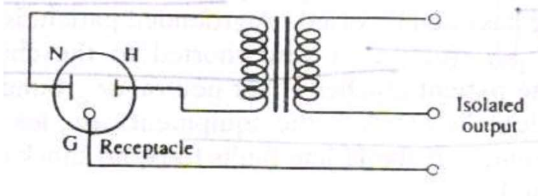


Fig**4.7.5.2 Isolation Transformer**

4.7.5.3 Line Isolation Monitor

A line isolation monitor (LIM) puts relatively large impedance from either secondary lead through an ammeter to ground of isolation transformer. If there is a conductive path through the equipment as shown in fig (b) the meter in the LIM will read a current. The meter on the LIM is calibrated to read the current flowing through a short circuit fault. An alarm in the LIM is usually set-off when a short circuit fault between secondary lead and ground would draw 2-5 mA current. This alarm indicates that the backup system has failed and the equipment is no longer isolated. If the equipment is critically needed, the LIM alarm may be overridden.

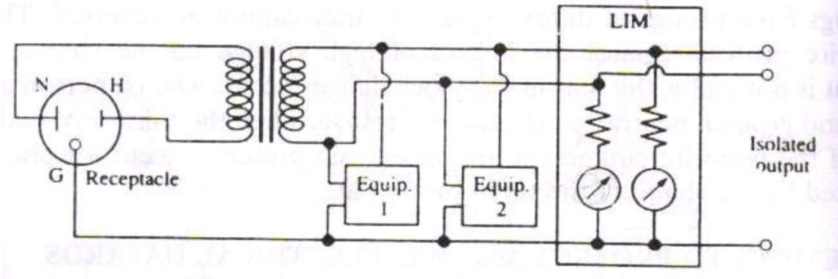


Fig 4.7.5.3 Line Isolation Monitor

TWO MARKS

1) What are the advantages of biotelemetry system

The advantages of biotelemetry systems are

(i). It is used to record the biosignals over long periods and while the Patient is engaged in his normal activities.

(ii). The medical attendant or computer can easily diagonise the nature of Disease by seeing the telemeter biosignals without attending patient Room

(iii). Patient is not disturbed during recording.

(iv). For recording on animals, particularly for research, the biotelemetry is greatly used.

2) Specify the frequencies used for biotelemetry

Wireless telemetry system uses modulating systems for transmitting biomedical signals. Two modulators are used here. A lower frequency sub-carrier is employed in addition to very- high frequency (VHF). This transmits the signal from the transmitter.