Draw the block diagram of ultrasonography machine and explain its operation.

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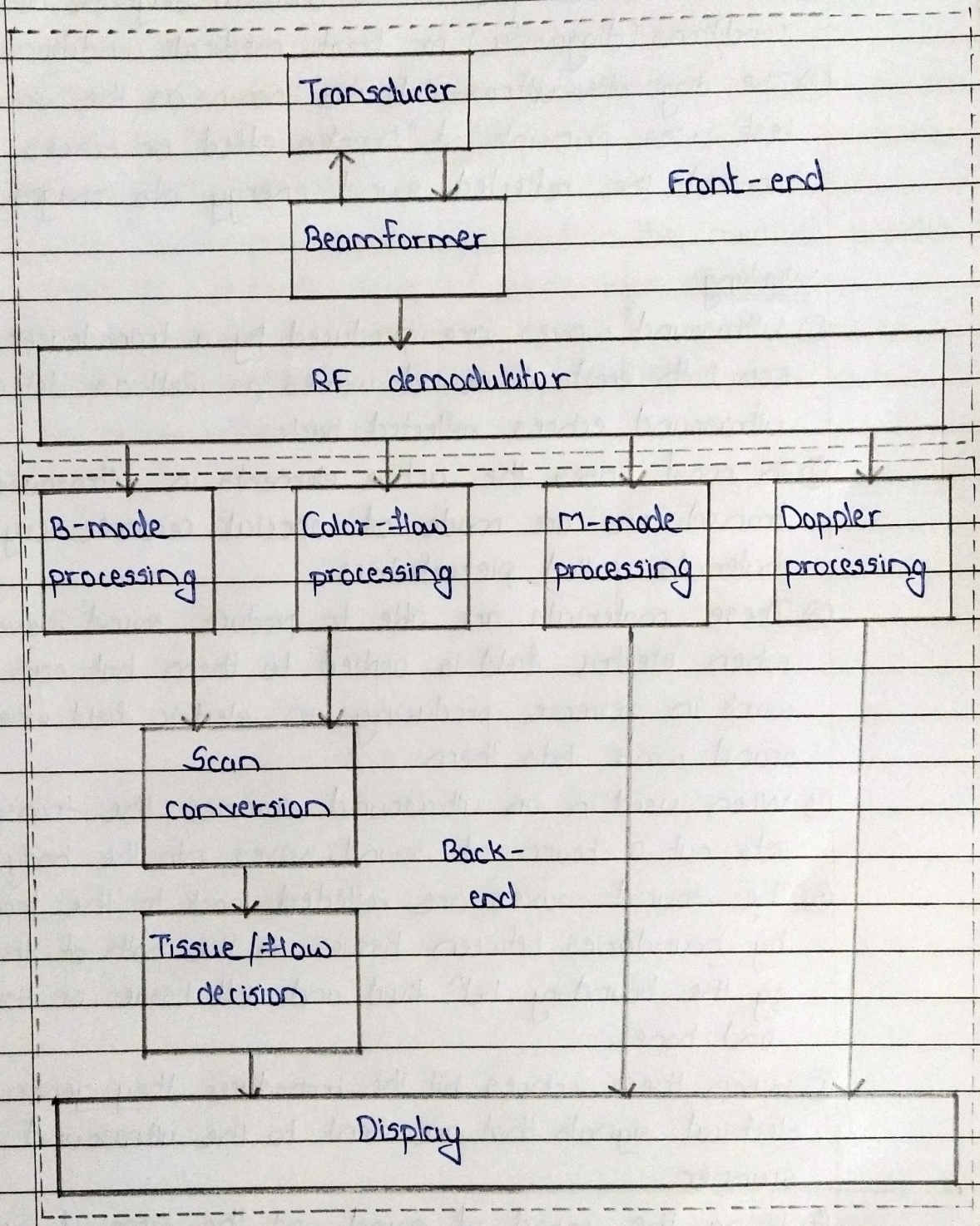

Block diagram of ultrasonography machine.

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① Ultrasonography (USG) is a popular diagnostic modality used in medical practice.

② The USG technique can be used to diagnose medical conditions (diagnostic) or treat medical conditions. (theraperutic)

③ The diagnostic ultrasound, also known as the sonography test, uses principle of "Doppler effect" or echoes to convert the reflected sound energy into images.

Working:

① Ultrasound waves are produced by a transducer, which can both emit ultrasound waves, as well as detect the ultrasound echoes reflected back.

② In most cases, the active elements in ultrasound transducers are made of special ceramic crystal materials called piezoelectrics.

③ These materials are able to produce sound waves when electric field is applied to them, but can also work in reverse, producing an electric field when a sound wave hits them.

④ When used in an ultrasound scanner, the transducer sets out a beam of sound waves into the body.

⑤ The sound waves are reflected back to the transducer by boundaries between tissues in the path of the beam eg. the boundary betn. fluid and soft tissue or tissue and bone.

⑥ When these echoes hit the transducer, they generate electrical signals that are sent to the ultrasound scanner.

⑦ Using the speed of sound and the time of each echo's return, the scanner calculates the distance from the transducer to the tissue boundary.

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(8) These distances are then used to generate two-dimensional images of tissues & organs.

(9) During an ultrasound exam, the technician will apply a gel to the skin.

(10) This keeps air pockets from forming betn. the transducer and the skin, which can block ultrasound waves from passing into the body.

(11) The sonography commonly used in the medical practice uses the B-mode and M-mode type of imaging.

(12) These techniques operate at sound wave frequencies that do not produce heat energy in the organ due to probe vibrations.

What are biological effects of MRI scanning?

→ ① Magnetic Resonance Imaging (MRI) is considered a safe technology since it just has the ability to change the position of atoms, but not to alter their structure, composition and properties, as the ionizing radiations attempt to do.

② However, as in any sanitary interventions, there are intrinsic hazards that must be understood, acknowledged and taken into consideration.

③ These hazards are relative to all three types of fields which can affect patients, staff and other persons within the MR environment.

④ To assess the potential dangerous biological effects associated with MRI environment and procedures, several studies have been conducted over the past thirty years, often producing controversial results.

⑤ Most of these studies are relative to the biological effects of a particular electromagnetic source utilized in MRI, while there is a lack of knowledge about the combination of three MF components.

⑥ Thus, there is a need to integrate the current findings to better understand the interactions betn. EMF related to MRI and biological systems.

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A] Effects of Static MF

1. Studies on human volunteers upto 8T, carried out to assess information about the information about the relationship betn. exposure to high static MFs and human health, took into account as endpoints central and peripheral nervous activities, behavioural and cognitive functions, sensory functions, cardiac fn., respiratory freq., body temperature, but no conclusion can be drawn.
2. Temporary and dose-correlated vertigo and nausea in workers and patients exposed to static MFs higher than 2T have been found in several studies, while the correlation betn. the exposure and the metallic taste has not been confirmed.
3. No significant differences among several physiological parameters (heart rate, blood pressure, blood oxygenation, core temperature, ECG, respiratory rate) have been checked during the exposure at 8T, together with complete reversible tachycardia imputable to the stress correlated with the exam.
4. Finally, acute neurobehavioral effects, such as eye-hand coordination speed and visual and auditive working memory problems after exposure to static fields at 1.5 and 3T have been reported for health volunteers.
5. A recent review summarizes the epidemiological evidences of static MF exposure and long-term health effects.

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B] Effects of Gradient MF

① During an MRI examination, the gradient MF, which serves for the spatial localization in the image reconstruction process, is switched on & off.

② For this reason, they are considered time varying MFs ranging betn. ELF and IF. Most of the available studies deal with possible association betn. residential ELF and cancer.

③ ELF MF has been classified in group 2B ("possibly carcinogenic to humans"), due to the possible association betn. residential MFs and childhood leukaemia.

④ The time variation induces in the patient undergoing a MR scan, an electric field which could stimulate nerves and muscles and could generate cardiac stimulation or even ventricular fibrillation. While the latter is a primary concern, being a life-threatening condition, possible peripheral nerve stimulation may cause discomfort and could not be tolerated by the subjects, thus interfering with the examination (eg. due to patient movements) or would result in a request to stop the examination.

⑤ A 2000's review analyzed patient safety in time varying gradient field associated to a MR scan and concluded that cardiac stimulation is very unlikely in present-day systems, while at sufficient amplitudes, peripheral nerve stimulation is perceptible and can cause patient discomfort.

c] Effects of RF Fields

① During an MRI scan, the patient is exposed to a time varying electromagnetic field in the RF range. It has been suggested that RF can induce effects via multiphoton absorption, i.e. through direct heating.

② Thus, biological effects caused by RF field can be classified into two categories:

i) non thermal effects: due to direct interactions betn. MFs and tissues.

ii) thermal effects: due to tissue heating caused by the induced electric current.

③ The non thermal effects have been less studied, however adverse effects mainly arise from a direct energy transfer from the field to the living system, which might be strongly non linear and are dependent on the field frequency.

④ The temperature increase of the tissues due to the RF energy absorption, depends on parameters such as the electrical and geometrical tissue properties, the type of RF pulse used, its repetition time and the frequency of the radiation.

⑤ The freqn. generally used in the MRI scanner are in a range at which high absorption occurs in the whole body.

⑥ Certain organs like such as the eye are particularly sensitive to heating due to lack of perfusion, so the presence of "hot spots" at those sites can be very dangerous for patient safety.

What are the common Imaging modalities. Explain MMRI system.

→ ① During image-guided neurosurgery, imaging is the most essential step because it is very difficult to reach the surgery target object when it is surrounded by the cranium

② Imaging provides the real time update of the surgical instrument location, which affects the procedure result.

③ The combination of Imaging and planning, postoperative phase is known as IGN (image-guided neurosurgery).

④ Various imaging modalities are used in IGN, but the selection of imaging modality depends on its speed of acquisition, image quality and comfort during surgery.

⑤ Common Imaging modalities are:

A] Computed Tomography

i) A CT scan involves a large, box like machine with a short tunnel.

ii) Computed Tomography is a medical test that creates multiple 2D and 3D images of internal parts of the body, which can be viewed on a computer system.

iii) For the treatment of any internal part of body, an image of the target area is required to analyze the abnormality in an area.

iv) The CT scan provides detailed information on the target area such as organ, soft tissue, blood vessels and many more.

B] Ultrasound

i) ultrasound or sonography is a portable, very low cost, easy-to-use and non-invasive process that does not use any ionizing radiation.

ii) The time range is seconds to minute and it can be used in the guidance stage with images of another modality.

iii) A special Doppler ultrasound method is a technology used to examine the blood flow in arteries, arms, legs and in all body parts.

C] Magnetic Resonance Imaging (MRI)

i) MRI is a radio technology scanner that uses radio waves and magnetic field and a computer system to produce a detailed picture of the tissue and organs.

ii) It is a strong magnetic field that provides a high-resolution image of soft tissue, which can be used in every stage of IGS.

D] Position Emission Tomography and Single Photon Emission Computed Tomography.

i) Position Emission Tomography (PET) : PET is a nuclear imaging technique that uses radiopharmaceutical to make a 3D image. The tracer used for PET emits particles known as positrons. The camera used in PET detects energy & produce image.

ii) Single Photon Emission Computed Tomography (SPECT): SPECT creates a 3D view of radiotracer molecules in the human body. To create 3D images, many projection images of the body at different time frames are needed.

E] Fluoroscopy

i) Fluoroscopy is an X-ray movie that shows X-ray images in a continuous form on the system.

ii) During a fluoroscopy process, an X-ray beam is moved across the body and these images are transferred to the system to see the movement of the body parts & the instrument.

F] Optical Method

i) The optical method is a non-invasive technique to look inside the body to acquire images of organs and tissue as well as cells and molecules using visible lights & special properties.

ii) The two most common optical methods are bioluminescence and fluoresence.

⑥ NMRI system:

i) Nuclear Magnetic Resonance Imaging (NMRI)

ii) A procedure in which radio waves and a powerful magnet linked to a computer are used to create detailed pictures of areas inside the body.

iii) These pictures can show the difference between normal and diseased tissue.

iv) Nuclear Magnetic Resonance Imaging makes better images of organs and soft tissue than other scanning techniques, such as computed tomography (CT) or X-ray.

v) NMRI is especially useful for imaging the brain, the spine, the soft tissue of joints and inside of bones.

vi) Also called as Magnetic Resonance Imaging, MRI & NMRI.

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What is a defibrillator and how does it work?
Explain Cardiac defibrillators with block diagram.

→ Defibrillator:

① Defibrillator are devices that restore a normal heartbeat by sending an electric pulse or shock to the heart.

② They are used to prevent or correct an arrhythmia, a heartbeat that is uneven or that is too slow or too fast.

③ Defibrillator can also restore the heart's beating if the heart suddenly stops.

④ Different types of Defibrillators work in different ways.

⑤ Automated external defibrillators (AEDs), which are in many public spaces, were developed to save the lives of people experiencing sudden cardiac arrest. Even untrained bystanders can use these devices in an emergency.

⑥ Other defibrillators can prevent sudden death among people who have a high risk of a life-threatening arrhythmia. They include implantable cardioverter defibrillators (ICD) which are surgically placed inside your body, and wearable cardioverter defibrillators (WCDs) which rest on the body.

Working of Defibrillator

There are 3 types of defibrillators: AEDs, ICDs and WCDs. Each type works by checking for arrhythmias or irregular heart rhythms. Once detected, each defibrillator will send a shock to restore a normal rhythm.

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① AED (Automated external defibrillators)

i) An AED is a lightweight, battery operated, portable device that checks the heart's rhythm and sends a shock to the heart to restore a normal rhythm.

ii) Sticky pads with sensors called electrodes are attached to the chest of somone who is having cardiac arrest.

iii) The electrodes send information about the person's heart rhythm to a computer in the AED.

iv) The computer analyzes the heart rhythm to find out whether an electric shock is needed. If needed, the electrode deliver shock.

② ICD (Implantable Cardioverter Defibrillators)

i) ICD are placed surgically in the chest or abdomen where it checks for arrhythmias. as it interrupt flow of blood, so ICD sends a shock to correct arrhythmia.

ii) An ICD can give off a low-energy shock to speed up or slow down an abnormal heart rate, which can correct a fast or irregular heartbeat.

iii) If low-energy shocks do not restore your normal heart rhythm, the device will switch to high-energy shocks for defibrillation.

iv) The device will also switch to high energy shocks if your ventricles start to quiver rather than contract strongly.

v) ICDs have a generator connected to wires to detect your heart's pulses & deliver a shock when needed.

③ WCD (Wearable Cardioverter Defibrillators)

i) WCDs have sensors that attatch to skin.

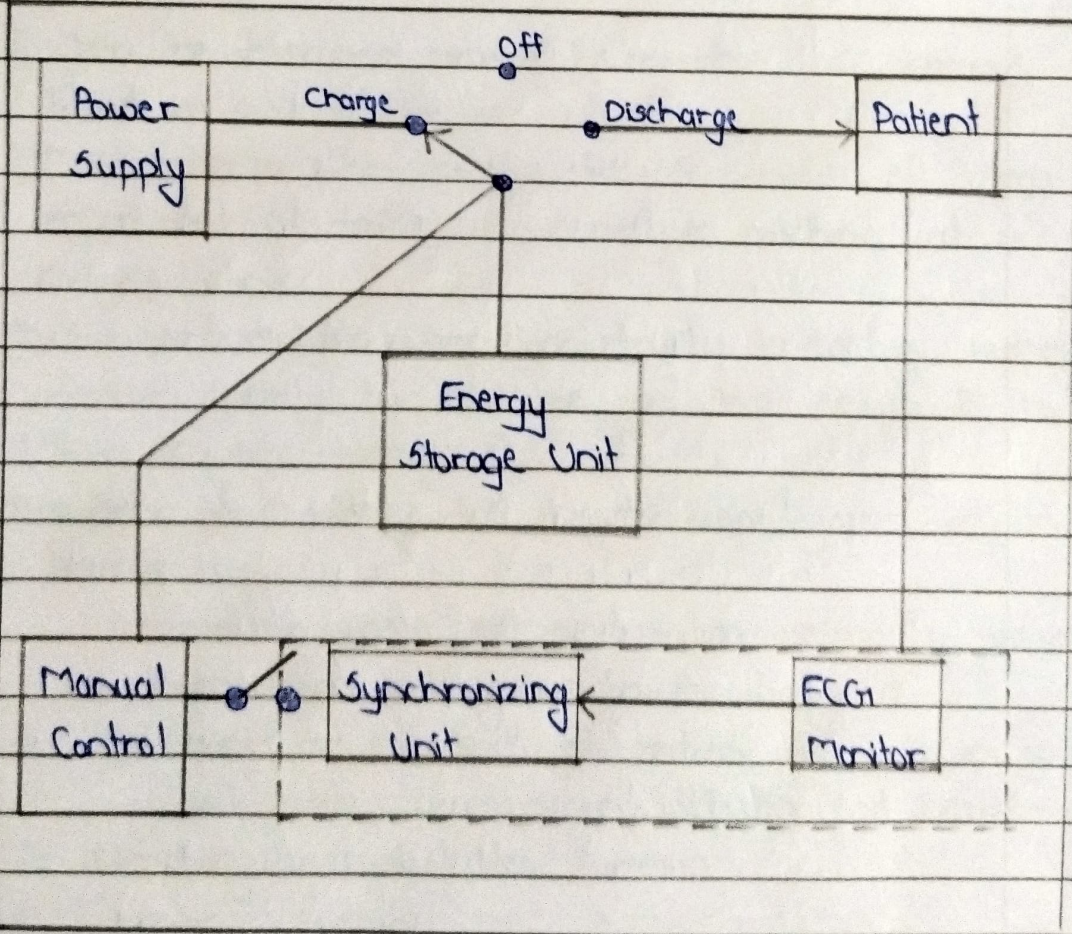
ii) They are connected by wires to a unit that checks your heart's rhythm and delivers shock when needed.

iii) Like an ICD, WCD delivers low to high energy shocks.

iv) The device is programmed to detect a particular heart rhythm.

v) The sensors detect when an arrhythmia occurs and notifies you with an alert.

<u>Block Diagram</u>



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What is need of dialyzer machine? What are the types of membranes used in the dialysis process?

→ ① A Dialysis machine used in dialysis that filters a patient's blood to remove excess water and waste products when kidneys are damaged, dysfunctional or missing.

② The didysis machine itself can be thought of as an artifical kidney.

③ Inside, it consists of more plastic tubing that carries the removed blood to the dialyzer, a bundle of hollow fibres that forms a semipermeable membrane for filtering out impurities.

④ In the dialyzer, blood is diffused with a saline sol^n called dialysate and the dialysate is in turn diffused with blood.

⑤ When the filteration process is complete, the cleaned blood is returned to the patient.

⑥ Most patients who undergo dialysis because of kidney impairment of failure use a dialysis machine at a dialysis clinic.

⑦ You need dialysis when you develop end stage kidney failure. Usually by the time you lose about 85 to 90% of your kidney f^n.

⑧ When your kidney fail, dialysis keeps your body in balance by:

i) removing waste, salt and extra water to prevent them from building up in the body.

ii) keeping a safe level of certain chemicals in your blood, such as potassium, sodium and bicarbonate.

iii) helping to control blood pressure.

Types of membranes used in dialysis process.

1. Unmodified cellulose membrane:
   i) Such as cuprophan are relatively inexpensive but also the most bioincompatible.
   ii) Cuprophan is a polysaccharide-based membrane obtained from pressed cotton.
   iii) It is composed of chains of glucosan rings with abundant free hydroxyl groups.
   iv) Cuprammonium is primarily used in manufacturing process of this membrane.

2. Modified / regenerated cellulose membrane.
   i) The modified cellulose membranes (such as those made of cellulose acetate or hemophan) have some or all of the hydroxyl groups esterified to make them more biocompatible.
   ii) However, such modifications may result in increased activation of the coagulation cascade & thus increase the anticoagulation requirement of the HD circuit.

3. Synthetic membrane.
   i) Synthetic membrane are made up of polysulphone, polycarbonate, polyamide or polyacryl-polyamide acrylate.
   ii) These membranes are bio compatible.
   iii) Synthetic membranes are generally more hydrophobic than cellulose membranes and therefore have higher adsorption properties.
   iv) Their increased ability to bind proteins may be partly responsible for improved biocompatibility.

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What are the types of pace maker? Explain any one pacemaker system.

→ Pacemaker:

① A pacemaker is a small device that's placed (implanted) in your chest to help control your heartbeat.

② It's used to prevent your heart from beating too slowly.

③ Implanting a pacemaker in your chest requires a surgical procedure.

④ A pacemaker is also called a Cardiac pacing device.

Types:

① Single chamber pacemaker: This type usually carries electrical impulses to the right ventricle of your heart.

② Dual chamber pacemaker: This type carries electrical impulses to the right ventricle and the right atrium of your heart to help control the timing of contractions between the two chambers.

③ Biventricular pacemaker: Biventricular pacing, also called cardiac resynchronization therapy, is for people who have a heart failure and heartbeat problems. This type of pacemaker stimulates both of the lower heart chambers (the right and left ventricles) to make the heart beat more efficiently.

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Explanation of: Biventricular pacemaker.

① This pacemaker, also known as Cardiac Resynchronization Theropy (CRT) device.

② It has three leads connected to the right atrium and both ventricles. we use the biventricular pacemaker to treat people with arrhythmias caused by advanced heart failure.

③ Heart failure means the heart's pumping power is weaker than normal. With heart failure, blood moves through the heart and body at a lower rate and pressure in the heart increases.

④ A delay betn. the contraction of the right and left ventricles often occurs with a heart failure, so the walls of the left ventricle are unable to contract at the same time.

⑤ working of Biventricular Pacemaker:

When your heart rate drops below the set rate (programmed by your doctor), the device generates (fire) small electrical impulses that pass through the leads to the heart muscles. These impulses make the lower chambers (ventricles) of the heart muscle contract, causing the right and left ventricles to pump together. The end result is improved cardiac function.

⑥ The CRT device (biventricular pacemaker) has 2 or 3 leads that are positioned in the:

1. Right atrium
2. Right ventricle
3. Left ventricle (via the coronary sinus vein)

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What are the scanning modes used in ultrasonography machines?

→ ① A-mode : A-mode (amplitude mode) is the simplest. A single transducer scans a line through the body with the echoes plotted on screen as a function of depth. Therapeutic ultrasound aimed at a specific tumor or calculus. is A-mode, to allow for pinpoint accurate focus of the destructive wave energy.

② B-mode or 2D mode: In B-mode (brightness mode), a linear array of transducers simultaneously scans a plane through the body that can be viewed as a 2D image on screen.

③ C-mode : A C-mode image is formed in a plane normal to B-mode image. A gate that selects data from a specific depth from an A-mode line is used; then the transducer is moved in the 2D plane to sample the entire region at this fixed depth.

④ M-mode : In M-mode (motion mode), pulses are emitted in quick succession - each time, either an A-mode or B-mode image is taken. Over time, this is analogous to recording a video in ultrasound. As the organ boundaries that produces reflections move relative to the probe, this can be used to determine the velocity of specific organ structure.

⑤ Doppler mode: This mode makes use of the Doppler effect in measuring and visualizing blood flow.

i) Color Doppler: velocity information is presented as a color-coded overlay on top of a B-mode image.

ii) Continuous wave (CW) Doppler: Doppler information is sampled along a line through the body and all velocities detected at each time point are presented.

iii) Pulse wave (PW) Doppler: Doppler information is sampled from only a small sample volume and presented on a timeline.

iv) Duplex: A common name for the simultaneous presentation of 2D and PW Doppler information.

6) Pulse inversion mode: Two successive pulses with opposite sign are emitted and then subtracted from each other. This implies that any linearly responding constituent will disappear while gases with non-linear compressibility stand out.

7) Harmonic mode: A deep penetrating fundamental freq. is emitted into the body and a harmonic overtone is detected. Noise and artifacts due to reverberation and aberration are greatly reduced.

What is thermography? How it is used for medical diagnosis.

→ ① Thermography is the process of using an infrared camera to look for abnormally hot or cold areas on a component operating under normal conditions.

② It is a viable non-destructive evaluation technique for the characterization of corrosion in metallic materials and is the simplest of all thermal inspection techniques.

③ The thermal camera captures and creates an image of an object by using infrared radiation emitted from the object in a process, which are examples of infrared imaging science.

④ Thermographic cameras usually detect radiation in the long-infrared range of the electromagnetic spectrum (roughly 9000 - 14000 nanometers) and produce images of that radiation, called thermograms.

⑤ The amount of radiation emitted by an object increases with temperature, therefore, thermography allows to see variations in temperature.

Usage of Thermography in Medical Diagnosis.

① Medical Thermography (digital infrared thermal imaging - DITI) is used as a method of research for early pre-clinical diagnosis and control during treatment of homeostatic imbalances.

② There are few devices, which operate in a passive method like infrared Thermography medicine; amongst these are the ECG and EEG.

③ The intrinsic safety of this method makes infrared Thermography free from any limitations.

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4. Thermography is a non-invasive, non contact tool that uses the heat from your body to aid in making diagnosis of a host of health care conditions.
5. Thermography is completely safe & uses no radiation.
6. The medical applications of DITI are extensive, particularly in the fields of Rheumatology, Neurology, Oncology, ~~By~~ Physiotherapy and sport medicine.
7. Medical Thermography equipment usually has two parts, the IR camera and a standard PC or Laptop computer. These systems have only a few controls and relatively easy to use.
8. Thermography is able to identify various disease patterns.
9. Imaging of smallest temperature difference in high resolution.
10. Thermal resolution of Infrared Camera systems determines a successful Analysis.

What are the types of biotelemetry system?

→ ① Biotelemetry is a method of measuring biological parameters from a distance.

② It is infact modification of existing methods of measuring physiological variables to a method of transmission of resulting data.

③ The transmission of data from the point of generation to the point of reception can be done in various ways.

④ Although the term commonly refers to wireless data transfer mechanisms (eg. using infrared systems), it also ensompasses data transferred over other media, such as telephone or computer network, optical link or other wired communications.

⑤ Many modern telemetry systems take advantage of the low cost and ubiquity of GSM networks by using SMS to receive and transmit telemetry data.

⑥ Bio telemetry is the measurement of biological parameters and for conveying biological information from a living organisms & its environment to a different location where this can be recorded.

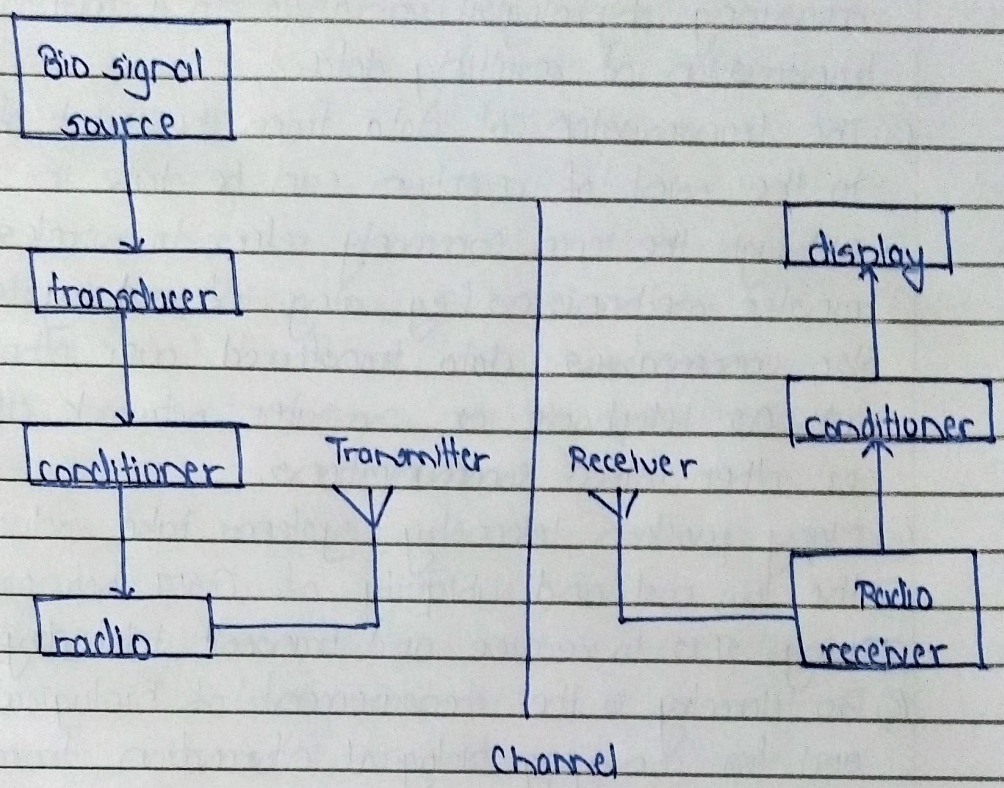
Types of Bio-telemetry system.

① Single channel bio-telemetry system.

i) For a single channel telemetry system, a miniature battery operated radio transmitter is connected to the electrodes of the patient.

ii) The transmitter broadcasts the biopotential to a remote place in which the receiver detects the radio signal and recover signal for further processing.

iii) The receiving system can be located in a room separately from the patients
iv) The only risk is shock to patient.



Block diagram of Single Channel Bio-telemetry system

v) Biosignal from the patient is converted into electrical signals by the transducer.
vi) The biosignals are amplified to radio freq. range of few hundred kHz to about 500kHz & then they are transmitted by transmitter antenna.
vii) At radio receiver the corresponding freq. are received and then they are demodulated, amplified and displayed.

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② Multi channel bio-telemetry system.

i) For most biomedical applications, simultaneous recording of Bio signals are required for correlation study.

ii) Each signal is in need of one channel.

iii) When the number of channels is more than the two or three, the simultaneous operation of the several single channel is difficult.

iv) At that time multiple channel bio-telemetry system is adopted.

v) For multichannel telemetry there are two multiplexing techniques:

a] Frequency Division

b] Time Division.

vi) The main advantage of multi-channel bio-telemetry is that patient making satisfactory recovery in a hospital can vacate the hard wired instrument beds in the ICU units, which provides positive psychological effect to the patient.