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Sawa University

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Third Stage

Radiological Equipment techniques

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Outline:

- Ultrasound Imaging Systems
- Components of an Ultrasound Imaging System
- Transducer Elements:
  - Piezoelectric Plate
  - Backing Layer
  - Matching Layer
  - Lens
- Developments in Transducer Technology

Ultrasound Imaging Systems

-Today, ultrasound (US) is one of the most commonly used imaging technologies in medicine. Sounds in the range 2 and 20 megahertz (MHz) are typically used for diagnostic ultrasound. The accuracy of ultrasound diagnosis based on computerized analysis of reflected ultrasound waves (echo.(

-The best resolution can be achieved by using shorter wavelengths, with a wavelength that is inversely proportional to the frequency. However, the use of high frequencies is limited due to the increased attenuation (loss of signal strength) in various tissues and so easily absorbed and shorter the depth of penetration.

Ultrasound Imaging Systems

- For this reason, specific probes are used for different frequency ranges to examine different parts of the body:

A- 3–5 MHz for abdominal areas.

B- 5–10 MHz for small and superficial parts.

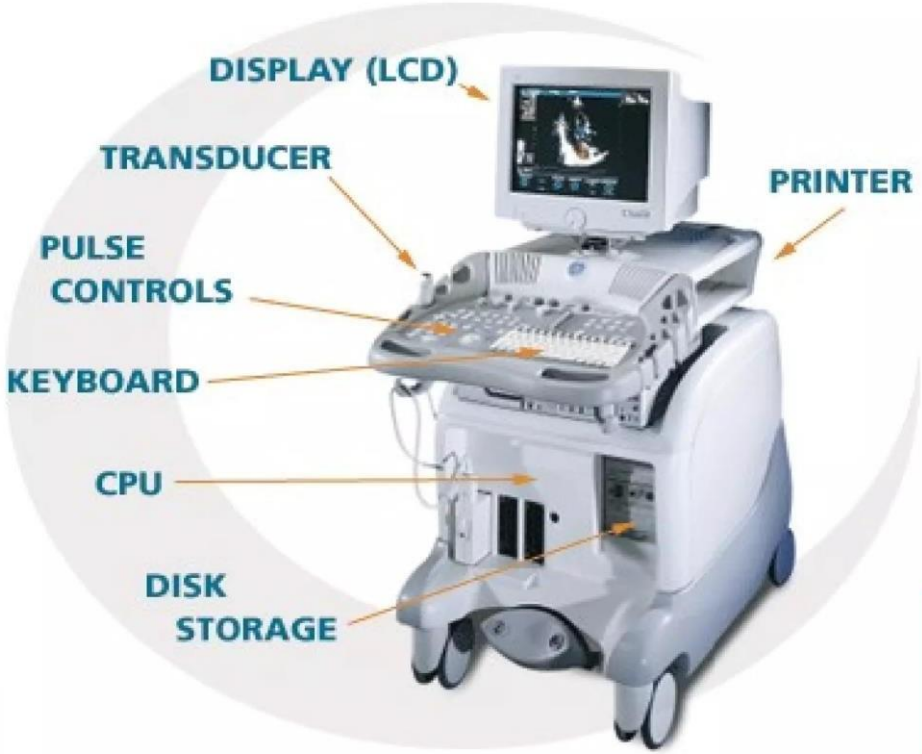
C- 10–30 MHz for the skin or the eyes.

-Because of the heterogeneity of the different tissues within the body with different densities, the ultrasonic waves penetrate varies accordingly. Bones absorb ultrasound much more than soft tissue, so that, in general, ultrasound is suitable for examining only the surfaces of the bone. For this reason, ultrasound images show a black zone behind the bones due to the inability of ultrasound energy to reach those areas.

Components of an Ultrasound Imaging System

The main components of an ultrasound imaging system are as follows:

1 Ultrasound transducer.
2 Display screen.
3 Pulse controls.
4 CPU and software.
5 Keyboard.
6 Printer.



Components of an Ultrasound Imaging System

1 Ultrasound Transducers: In general, a transducer is a device that converts energy from one form to another, in the case of Ultrasound transducers; the conversion is from electrical to mechanical energy (or vice versa.(

2 Display screen: displays the image from the ultrasound data processed by the central processing unit.

3 Pulse controls: changes the amplitude, frequency and duration of the pulses emitted from the transducer probe.

4 CPU And Software :Central Processing Unit, sends electrical signals to the transducer probe which converts them into the sound waves, then travel into the body and back as echoes. The transducer collects these echoes and converts them back into electrical signals, which are then sent to the CPU, which processes these signals performing to convert them into an image displayed on the monitor.

5 Keyboard: inputs data and takes measurements from the display.

6 Printer: prints the image from the displayed data.

Transducer Elements:

-Transducers (scanning probes) is the most expensive part of any ultrasound unit. The US unit contains one or more transducers that transmit the ultrasound pulses and receive back the echoes during scanning.

It is the hand-held part of the ultrasound machine that is responsible for the production and detection of ultrasound waves.

Transducer Elements:

The main components of the ultrasonic transducers are as the following:

-1Piezoelectric Plate: The piezoelectric plate is the heart of any ultrasound transducer, It operates based on the piezoelectric effect, which converts mechanical energy into electrical energy and vice versa.

Ultrasound transducers are usually made of thin discs of an artificial material such as PZT (lead zirconate titanate). The crystal is cut into a slice with a thickness equal to half a wavelength of the desired ultrasound frequency.

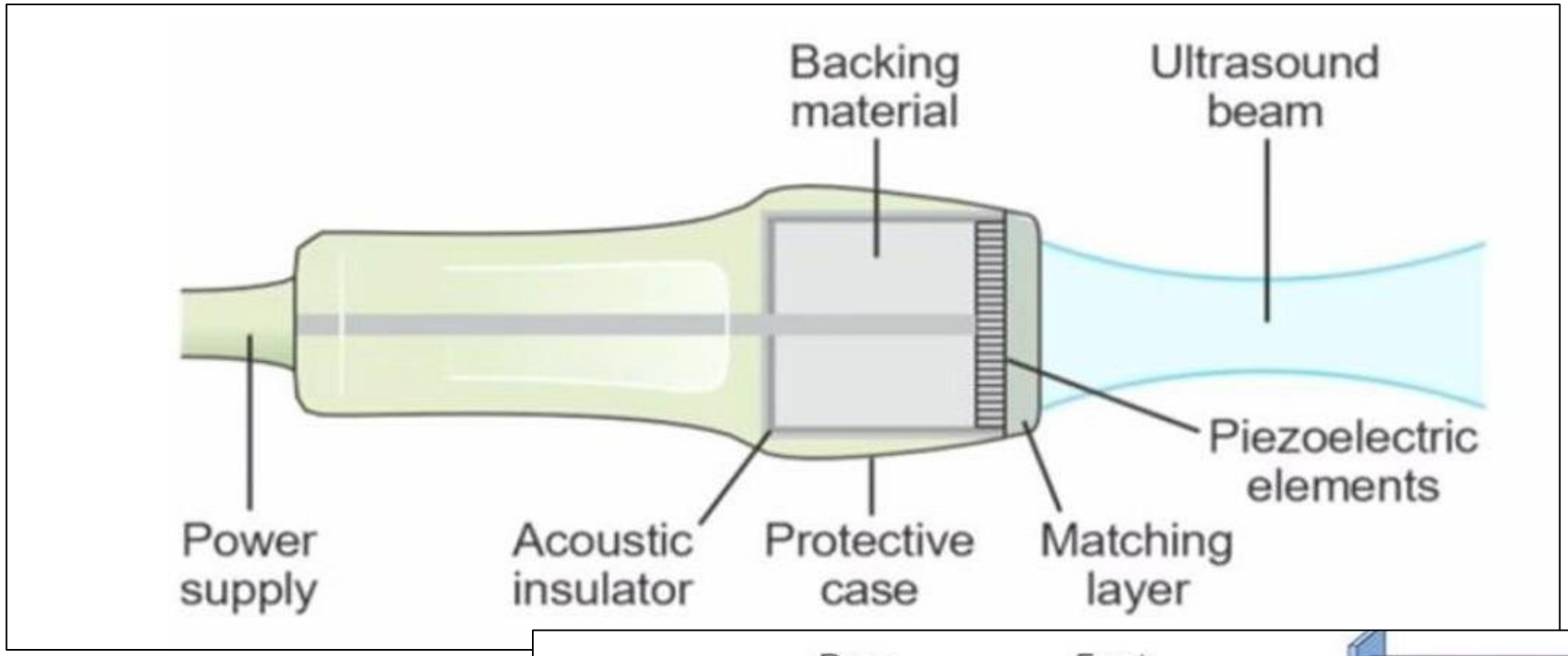
Generally, the thickness of thin discs (usually 0.1–1 mm) determines the ultrasound frequency. a thicker element produces a lower frequency oscillation while a thinner element produces a higher frequency oscillation.

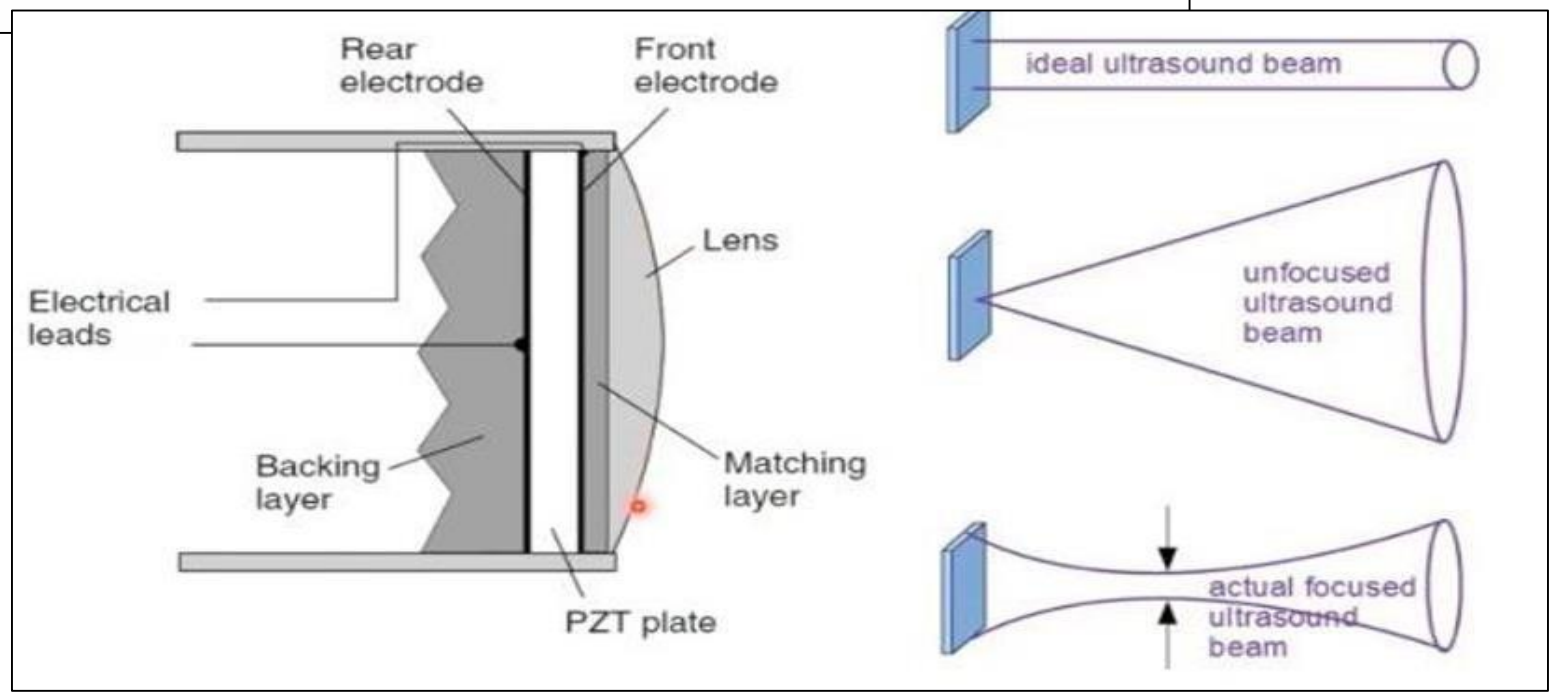
-2Backing Layer: adhered to the back of the Piezoelectric ccrystal, its damping excess vibrations of the piezoelectric Plate, improves axial resolution by shortening pulse duration and prevents unwanted ultrasound waves from continued transmission.

3 Matching Layer: allows close to 100% transmission of the ultrasound waves from the element into the tissues by minimizing reflection due to traversing different mediums (acoustic impedance). Bridges acoustic impedance mismatch between the piezoelectric plate and the body.

4 The Lens: Focuses the ultrasound beam to improve spatial Resolution. Controls the beam's width and shape for better imaging. Reduces beam divergence in the far field.

5 Housing: for electrical insulation and protection of the element.


Backing material
Ultrasound beam
Piezoelectric elements
Power supply
Acoustic insulator
Protective case
Matching layer


Rear electrode
Front electrode
Lens
Electrical leads
Backing layer
Matching layer
PZT plate
ideal ultrasound beam
unfocused ultrasound beam
actual focused ultrasound beam

Developments in Transducer Technology

1. Miniaturization: Smaller probes for minimally invasive procedures.

2. Broadband Transducers: Increased bandwidth for better resolution.

3. Matrix Arrays: Enable 3D and 4D imaging for real-time volumetric data.