PRINCIPAL OF ULTRASONIC MEASUREMENT

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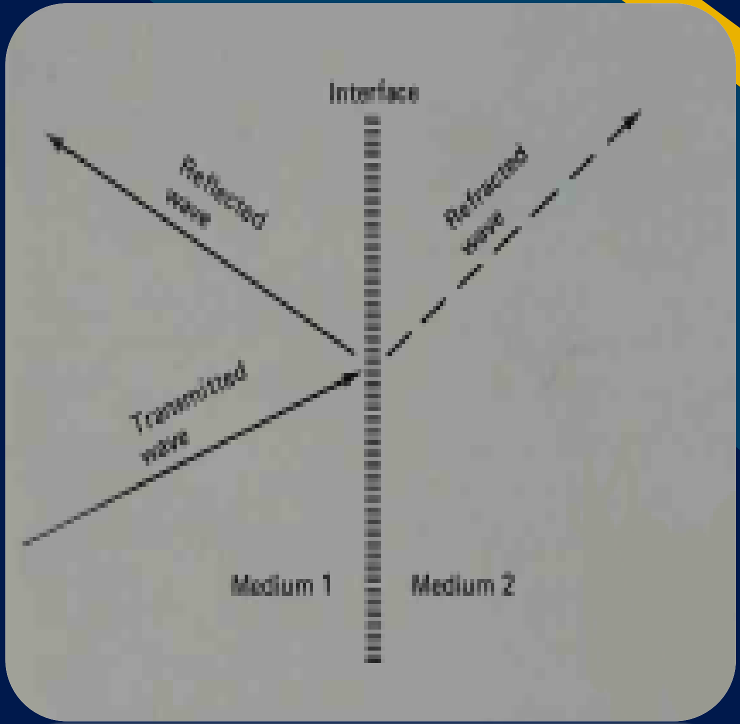
ULTRASOUND

- Ultrasound has played a major role in many of the innovation in the field of medicine
- ultrasound is sonic energy at frequencies above the audible range (greater than 20 kHz).
- Its use in medical diagnosis is from the period of world war II and also used in military development of sonar

Properties of Ultrasound

- ✓ Ultrasound exists as a sequence of alternate compressions and rarefactions of a suitable medium (air, water, bone, tissue, etc.) and is propagated through that medium at some velocity.
- ✓ Behavior depends on the frequency of sonic energy and the density of the medium it travels
- ✓ At the frequencies normally used in diagnostic applications, ultrasound can be focused into a beam and obeys the laws of reflection and refraction.
- ✓ When a beam of ultrasound passes from one medium to another, a portion of the sonic energy is reflected and the remainder is refracted
- ✓ Amount of energy reflected depends on the difference in density between the two media and the angle of transmitted beam strikes the medium.
- ✓ The greater the difference in media, the greater will be the amount reflected.
- ✓ The nearer the angle of incidence between the beam and the interface is to 90 ° the greater will be the reflected portion.



Properties of Ultrasound

- ✓ At interfaces of extreme difference in media, such as between tissue and bone or tissues and a gas, almost all the energy will be reflected and practically none will continue through the second medium.
- ✓ For this reason, the propagation path for ultrasound into or through the body must not include bone or any gaseous medium, such as air.
- ✓ In applying ultrasound to the body, an airless contact is usually produced through use of an aqueous gel or a water bag between the transducer and the skin.

BASIC MODES OF TRANSMISSION

- Pulsed Ultrasound
- Continuous Doppler
- Pulsed Doppler
- Range Gated Pulsed Doppler

Pulsed Ultrasound

- ✓ In this mode, ultrasound is transmitted in short bursts at a repetition rate ranging from 1 to 12 kHz.
- ✓ Returning echoes are displayed as a function of time after transmission, which is proportional to the distance from the source to the interface.
- ✓ Movement of interfaces with respect to time can also be displayed.
- ✓ The burst duration is generally about 1 micro sec. Pulsed ultrasound is used in most imaging applications.

Continuous Doppler

- ✓ A continuous ultrasonic signal is transmitted while returning echoes are picked up by a separate receiving transducer.
- ✓ Frequency shifts due to moving interfaces are detected and recorded and the average velocity of the targets is usually determined as a function of time
- ✓ This mode always requires two transducer crystals, one for transmission and one for receiving, whereas any of the pulsed modes can use either one or two crystals.
- ✓ Continuous Doppler ultrasound is used in blood flow measurements and in other applications in which the average velocity is measured without regard to the distance of the sources.

Pulsed Doppler

- ✓ As in pulsed ultrasound, short bursts of ultrasonic energy are transmitted and the returning echoes are received.
- ✓ However, in this mode frequency shifts due to movement of the reflected interfaces can be measured in order to determine their velocities.
- ✓ Thus, both the velocity and distance of a moving target can be measured.
- ✓ In a typical application, three cycles of 3-MHz ultrasound are transmitted per pulse at a pulse rate of 4 to 12 kHz.

Range Gated Pulsed Doppler

- ✓ This mode is a refinement of pulsed-Doppler ultrasound.
- ✓ A gating circuit permits measurement of the velocity of targets at a specific distance from the transducer.
- ✓ The velocity of these targets can be measured as a function of time.
- ✓ With range-gated pulsed Doppler ultrasound, the velocity of blood can be measured, not only as a function of time, but also as a function of the distance from the vessel wall.

ULTRASONIC IMAGING

- ✓ The most widely used applications of ultrasound in diagnostic medicine involve the noninvasive imaging of internal organs or structures of the body.
- ✓ Such imaging can provide valuable information regarding the size, location, displacement, or velocity of a given structure without the necessity of surgery or the use of potentially harmful radiation.
- ✓ Tumors and other regions of an organ that differ in density from surrounding tissues can be detected.
- ✓ In many instances, ultrasonic techniques have replaced more risky or more traumatic procedures in clinical diagnosis.
- ✓ Imaging systems generally utilize the pulsed ultrasound or pulsed Doppler mode.
- ✓ Instrumentation must include an electrical signal source capable of driving the transmitter, which consists of a piezoelectric crystal.
- ✓ The same crystal can be used for receiving echoes or a second crystal may be used.
- ✓ After amplification, the received information is displayed in one of several display modes.

TYPES OF ULTRASONIC DISPLAY MODES

A Scan Display

B Scan Display

M Scan Display

A Scan Display

- Simplest form of display.
- Each transmitted pulse triggers the sweep of an oscilloscope.
- That pulse (often attenuated) and the returning echoes are displayed as vertical deflections on the trace.
- The sweep is calibrated in units of distance, and may provide several ranges in order to accurately determine the distance of the interfaces of interest.
- Often, the amplifier gain is varied with the sweep to compensate for the lower amplitude of more distant echoes.
- In most cases the transducer is kept stationary so that any movement of echoes along the trace will be the result of moving targets.
- Example: Echoencephalogram.

A Scan Display

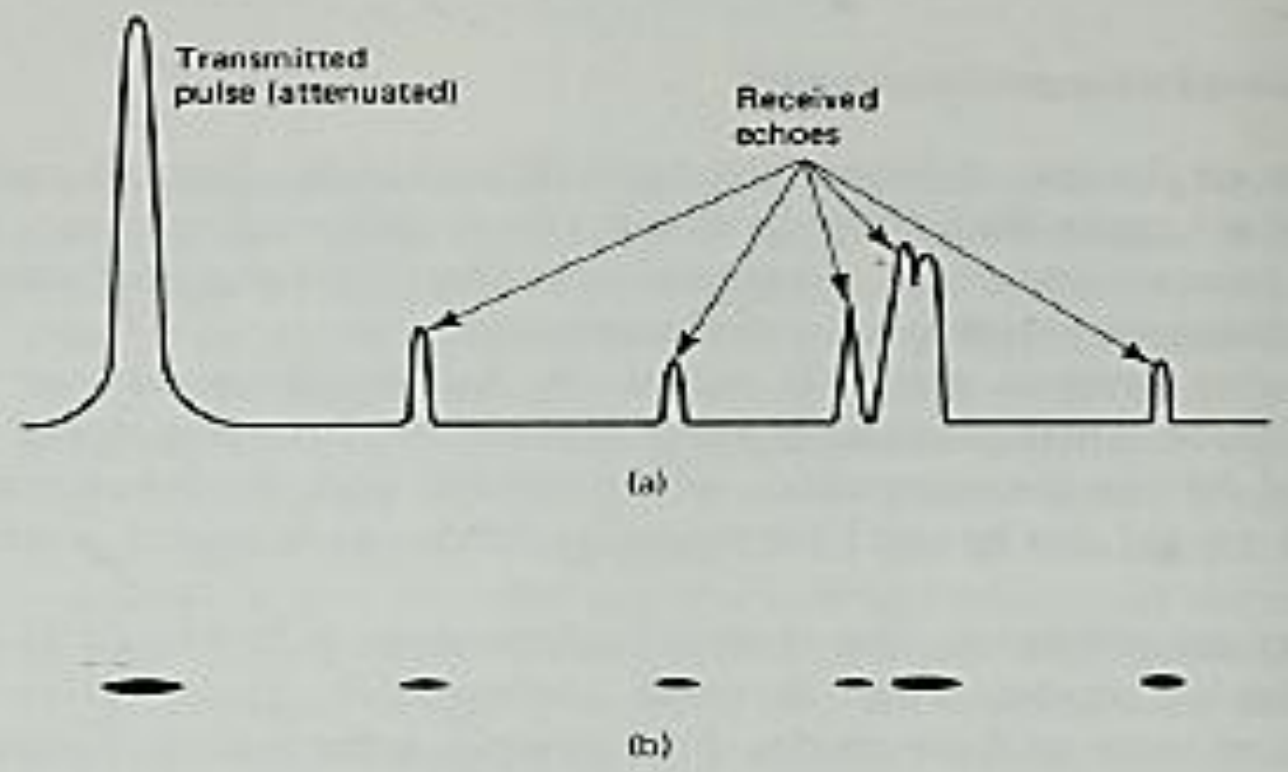


Figure 9.8. Ultrasound Display Principles. (a) Typical A-scan. Echoes cause vertical deflection of oscilloscope pattern. (b) Corresponding display in which echoes control brightness of oscilloscope beam. This principle is used in both B- and M- scan displays.

M Scan Display

- In this the received pulses are used to brighten the trace rather than control the vertical deflection.
- For the M-scan, the transducer is held stationary so that the movement of the dots along the sweep represent movement of received targets.
- If photographic paper is slowly moved past the face of the oscilloscope so that each trace lies immediately adjacent to the one preceding it, the dot representing each target will trace a line on the paper
- A stationary target will trace a straight line, whereas a moving target will trace the pattern of its movement with respect to time.
- A light-pen recorder in which the intensity of the light source can be controlled may be used instead of an oscilloscope to produce a chart record of the movement of echoes with respect to time.
- Example : Echocardiogram

M Scan Display

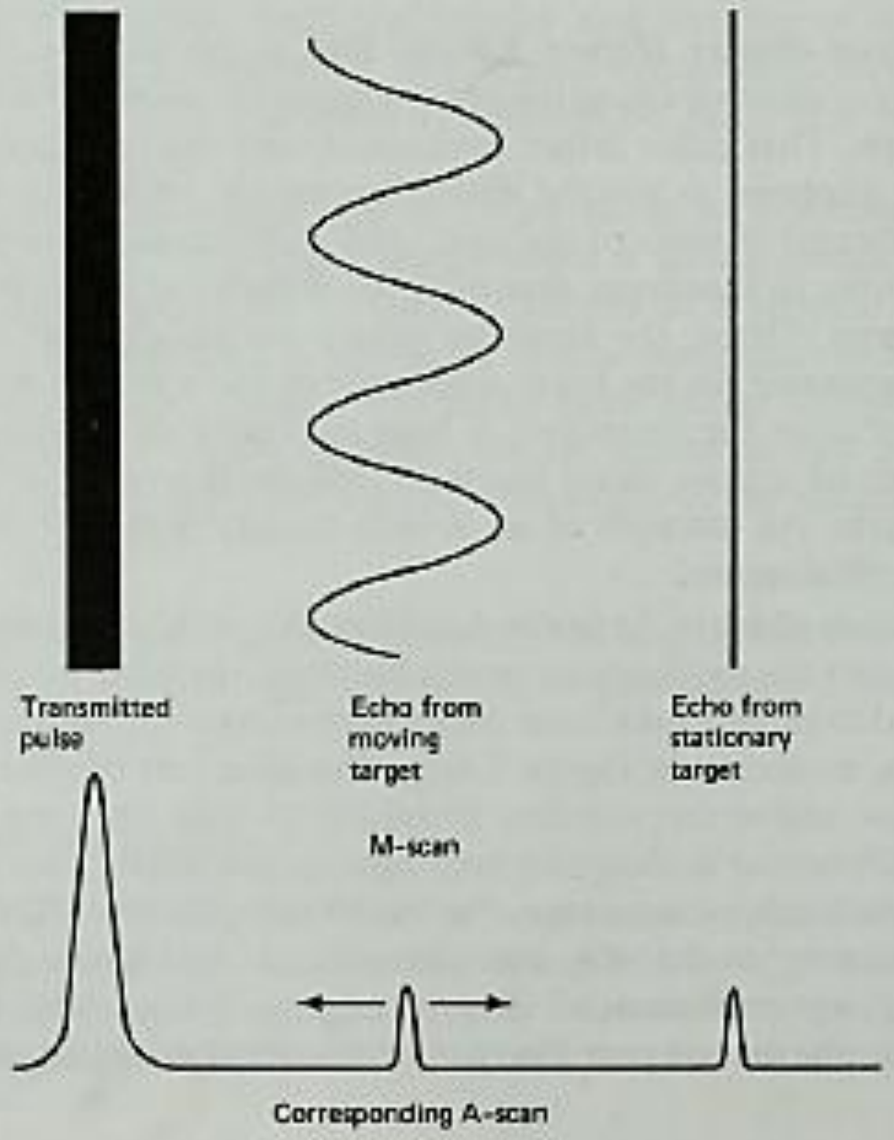


Figure 9.9 M-scan of moving and stationary target with corresponding A-scan.

B Scan Display

- While the M-scan is used to display the movement of targets with respect to time, the B-scan presents a two-dimensional image of a stationary organ or body structure.
- In the B-scan the transducer is moved with respect to the body while the vertical deflection of the oscilloscope or movement of the chart paper is made to correspond to the movement of the transducer.
- The movement may be linear, circular, or a combination of the two, but where it is anything other than Linear, the sweep must be made to compensate for the variations in order to provide a true 2D display of the segment being scanned.
- Example:

B Scan Display

Figure 9.14. Ophthalmic B-scan with camera. (Courtesy of Storz Instrument Co., St. Louis, MO.).

Thank You.

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