Lab exercise: The Pulse-Echo Principle

In most medical applications of ultrasound, the pulse-echo principle is used. In this lab exercise, you will get acquainted with this method. You will conduct measurements in a water bath and study how the ultrasound beam is reflected, refracted and absorbed.

Materials:

Oscilloscope
Ultrasound transducer
Panametrics pulser/reciever
Acrylic reflector
Rubber block
Metal wire
Positioning equipment
Water tank

Literature:

Chapters 1-3 in *Diagnostic Ultrasound*

Tasks:

Working Principles and Components of the Pulse-Echo System.

Set up a simple pulse-echo system according to the following instructions:

- Mount a transducer in the water tank using the positioning equipment. Align the transducer perpendicular to the flat surface of the acrylic reflector. The distance between the transducer and the reflector should be approximately 5 cm.

- Connect the transducer, pulser/receiver, and oscilloscope into a pulse-echo system. Configure the oscilloscope, adjust the pulser/receiver, transducer, and reflector to optimize the signal from the echo (maximize the amplitude).

- Identify the different echo signals.

- Study how the echo signals are affected when you:
  Change the distance and angle between transducer and reflector
  Change the pulse amplitude
  Change the pulse repetition frequency (ghost echoes?)

- **Bonus task:** In a pulse-echo system, the transducer is used both in transmitter and receiver mode. The amplitude of the electrical transmit pulse is approximately 100 V and that of the echo is well under 1 V. How are the electronics adapted to handle such a large span of amplitudes?

Spectrum of the Echo Pulse.

The FFT function of the oscilloscope can be used to analyze the frequency content of a signal.

- Determine the frequency content of the echo signal.
- Does the angle of incidence affect the frequency content?
- Is the frequency content affected if a sound absorbing material is placed between transducer and reflector?

Speed of Sound and Acoustic Impedance.

Two material parameters that greatly affect the properties of the pulse-echo system are speed of sound and acoustic impedance.

- Determine the speed of sound in: Water: _______________ m/s

  Acrylic glass: _______________ m/s

- Determine the acoustic impedance of: Water: _______________ kg/m^2s

  Acrylic glass: _______________ kg/m^2s

Reflection Coefficient.

The amplitude of a reflection from an interface depends on the reflection coefficient.

- Calculate the reflection coefficient (of amplitude) of acrylic glass in water.

  $R_{acrylic}$ = _______________

- Measure the amplitude of the echo from the acrylic glass surface and compare with the signal from the black rubber block.

  $A_{acrylic}$ = _______________

  A_{rubber} = _______________

- Estimate the reflection coefficient of the black rubber block based on previously calculated and measured quantities.

  R_{rubber} = _______________

Spatial Resolution.

The spatial resolution of a pulse-echo system determines the detection limit for small structures. The resolution may be separated into two components: axial and lateral resolution.

- Suggest how these parameters could be measured using the equipment listed in the materials section.

- Measure the resolution of the pulse-echo system at a distance of approximately 5 cm and 25 cm in water.

Distance:	5 cm	25 cm
Axial resolution:		
Lateral resolution:		