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Exercise 3 – Pulse Echo Imaging

Purpose: To understand the concept of pulse-echo imaging in ultrasound.

Deadline: See It's Learning

Matlab code: *PulseEcho.m* contains a simple simulation for an ultrasound pulse echo system. This is the basis for solving the exercises. The file is downloadable from It's Learning.

Exercises

1. Draw a block diagram of the pulse-echo system (This is not expected to be handed in).
2. Consider an object of 1 cm thick layer of fat submerged in water, at depth 2 cm. Vary the pulse length Tp and center frequency f0.
    a. Which values for Tp and f0 gives good resolution?
    b. Which values for Tp and f0 gives good signal to noise ratio?
    c. Suggest a value for Tp and f0 that both gives good resolution and good signal to noise ratio.
3. Vary the thickness of the fatty layer. Look in particular at thicknesses = $\lambda/2$, $\lambda/4$.
    a. Explain what happens.
    b. Try to formulate an expression for the received signal and look at the amplitude when the thickness is $\lambda/2$ and $\lambda/4$. (Some useful equations are given in a separate pdf file).
4. We shall now take a look at the signal from muscular tissue (2cm thick) in water (at depth 1cm). The acoustic impedance is on average $1.66\frac{\text{kg}}{\text{m}^2\text{s}}$, and we assume that the impedance varies periodically (sine function) with an amplitude of $0.02\frac{\text{kg}}{\text{m}^2\text{s}}$, and period 0.385 mm.
    a. Plot the received signal for frequencies f0 = 2.0 MHz and 4.0 MHz (pulse length Tp=2e-6).
    b. Why is the signal so different for the two frequencies used?
5. We shall now turn to a piece of liver, 2cm thick, at a distance of 1cm. The acoustic impedance for liver is on average $1.66\frac{\text{kg}}{\text{m}^2\text{s}}$, with a Gaussian distributed spatial fluctuation, with a standard deviation of $0.02\frac{\text{kg}}{\text{m}^2\text{s}}$. We assume that the correlation length is less than 0.01 mm.
    a. Plot the received signal using two pulse lengths (f0=2.5 MHz) Tp= 0.6e-6 and Tp=1.8e-6.
    b. Simulate several times, and observe how the speckle-pattern varies. Try to explain what happens.

Good Luck!