NBE-E4310 D - Biomedical Ultrasonics 2023

Independent/group work 28.09.2023 at 12-14; Submission: Please submit your responses via MyCourses as one zip file containing your responses in pdf and Matlab/Python format. The deadline for submitting your Exercise 1 responses is at 1:00 PM on October 5, 2023.

Please, note that not all details needed for the exercises have been necessarily presented during the lectures. If missing information, please refer to open sources or course book. Students are expected to have basic knowledge of signal processing and Matlab/Python skills.

TASK 1 (8 points)

Please, consider the real pressure from a planar source that produces sound bursts that propagate in water. Then consider the vector t, where t represents the time points where the pressure was measured. Assume that the signal is measured at the spatial peak of the acoustic field. The files containing the pressure and time vectors can be found on MyCourses course website. The time is expressed in seconds and pressure in Pascals.

a. Plot the pressure as a function of time, including the labels with variable symbols and units. (1p)

b. Plot the instantaneous intensity as a function of time, including the labels with variable symbols and units. (1p)

Define then the following:

c. Period of the wave (1p)

d. PPP (1p)

e. PNP (1p)

f. PRP (1p)

g. PRF (1p)

h. PD (1p)

TASK 2 (9 points)

Using the previous data from Task 1, define the following:

a. I_{SPTP} (3p)

b. I_{SPPA} (3p)

c. I_{SPTA} (3p)

TASK 3 (6 points)

a. Generate a 1D, continuous planar wave traveling along dimension x in longitudinal mode, operating at a frequency of 1 MHz and a pressure amplitude of 1 MPa. Calculate the pressure in complex form and define the real and absolute pressure for 5 cycles. (2p)

b. Generate the same wave as before, but from a depth from 0 to 5 cm, adding the attenuation of:

1. tissue (1p)

2. muscle (1p)

3. fat (1p)

4. bone (1p)

Plot separately the real and absolute of the pressure as a function of depth. Consider the attenuation coefficients and speed of sounds of each material. Assume t=0.

TASK 4 (10 points)

Derive the geometric attenuation terms for intensity and pressure. Assume that there is only attenuation from the geometric factor (Hint! Assume conservation of energy in lossless media. Intensity is the energy flux):

a. For a line source (5p)

b. For a point source (5p)