# NBE-E4310 - Biomedical Ultrasonics

## EXERCISE 1 (30 points)

Independent/group work 17.1.2019 at 12-14; correct solutions 28.1.2019 at 16-18

*Submission: Please submit your responses via MyCourses as one zip file containing your responses in pdf and Matlab format. The deadline for submitting your Exercise 1 responses is at 1:00 PM on Jan 28, 2019.*

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

During the lab demo of 10.1.2019 we made measurements at the acoustic focus of the beam of a focused piezoelectric transducer. The Schlieren images below demonstrates three time points (1$^{st}$ image: arriving wave; 2$^{nd}$ image incident wave; 3$^{rd}$ image exiting wave) of the recorded sound burst at focus, i.e. the burst travels from right to left:
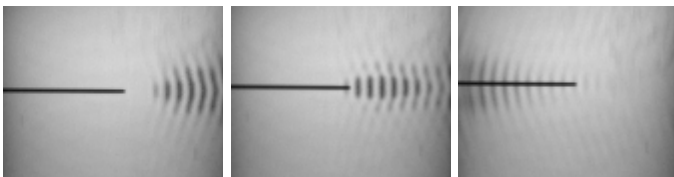


When the burst meets the needle hydrophone, the hydrophone records the pressure fluctuations at the needle hydrophone tip as a function of time. The file *demo1.mat* contains three vectors: time (s), hydrophone signal (V) and driving signal of the signal generator (V). Beginning of the driving signal represents the time point when the sound emission begins.

### 1. Measures of an ultrasound burst (10p)

Based on the given signals, please define the following:

   a) Plot the hydrophone signal (V) and the driving signal (V) as a function of time (μs). Label clearly parameters and units. 1p
   b) What is the PRP? 1p
   c) What is the PRF? 1p
   d) Plot the amplitude spectrum of the pressure signal in decibels. Choose the refence value to be the maximum value of the spectrum. 2p
   e) What is the -6dB bandwidth of the burst? 2p
   f) What is the peak frequency of the amplitude spectrum? 1p
   g) What is the center frequency of the amplitude spectrum? 1p
   h) What is the approx. maximum frequency of the amplitude spectrum? 1p

   You can define some values graphically, but make sure you explain or visualize how you got the values.

## 2. Speed of sound in water (5p)

Based on the given signals, please define the following:

a) What is the time that takes for the pulse to travel from the transducer to hydrophone? 1p
b) Considering the hydrophone is at the geometric focus of a spherical bowl transducer (aperture = 60 mm, R = 75 mm), what is the speed of sound in water? 2p
c) What must be the temperature of the water considering it is distilled water? 2p

## 3. Pressure and intensity measures of an ultrasound burst (15p)

Based on the given signals, please define the following:

a) Convert the pressure signal to MPa and present it as a function of time (µs). Use the frequency information presented in task 1 and table below. 2p
b) What is the PPP? 1p
c) What is the PNP? 1p
d) What is the PD? 1p
e) What is the instantaneous intensity at PPP? 1p
f) What is the instantaneous intensity at PNP? 1p
g) What is the $I_{SPPA}$ (Spatial Peak, Pulse Average) of the signal? 3p
h) What is the $I_{SPTA}$ (Spatial Peak, Time Average) of the signal? 3p
i) What is the duty cycle of the driving signal? 1p
j) What is the duty cycle of your pressure signal? 1p

| Frequency (MHz) | Sensitivity (mV/MPa) |
|---|---|
| 1 | 46 |
| 2 | 66 |
| 3 | 71 |
| 4 | 66 |
| 5 | 56 |
| 6 | 61 |
| 7 | 55 |
| 8 | 45 |
| 9 | 57 |
| 10 | 52 |