PW n°3: Study of an ultra-sound emitter- Determination of sound wave velocity in air.

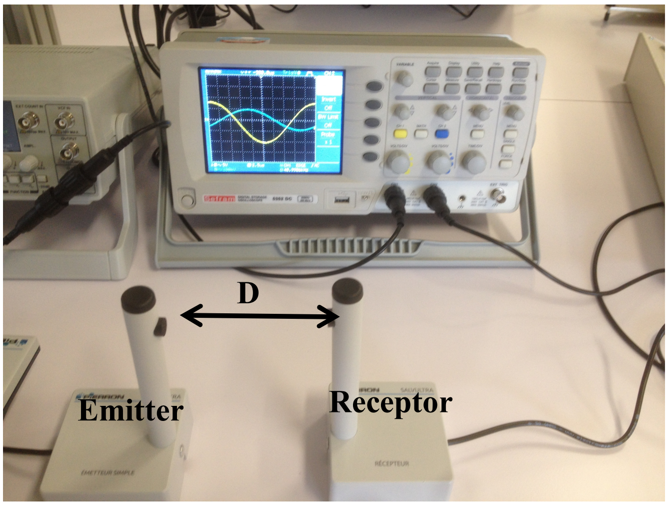

Figure 1.

I Introduction

Sound is a mechanic wave that propagates in space and time in a material media. We propose to study the case of ultra-sounds (that have a frequency higher than 20 kHz) with the help of ultra-sound emitter and receptor.

The goal is to study first the emitter that is a piezo-electric cell excited by a wave generator. Then we will determine the sound wave velocity by measuring the wavelength of the wave.

II. Manipulation

- Turn on the wave generator, and with a T connector send the signal both to the emitter and to the CH1 terminal of the oscilloscope. By that way you can see the signal sent to the emitter. Set up the frequency generator with a sinusoidal wave around 40 kHz.
- Plug the BNC cable of the receptor into the CH2 Terminal of the oscilloscope.
- Put the receptor in front of the emitter and try to observe a signal in CH2 (like depicted in Figure 1).
- What happens when moving the receptor ?

II.1) Frequency dependence of the emitter

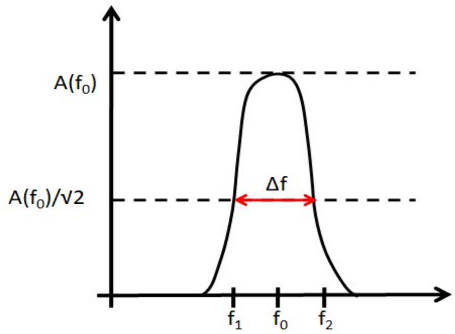

Figure 2.

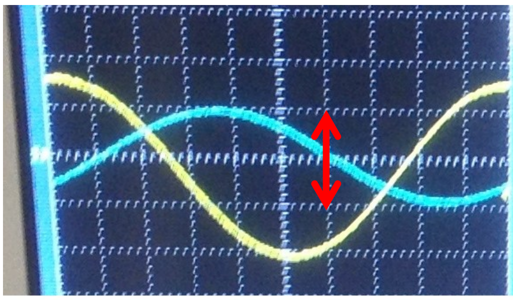
Figure 3.

The emitter is supposed to have a maximal amplitude when the frequency of excitation is 40 kHz. However this value can be a bit different. The goal of that part is to determine exactly what is the frequency for which the signal has the maximum amplitude.

- Put again the receptor in front of the emitter at a distance close to 20 cm. Check that the directions are well aligned and note exactly the distance between the emiiter and the receptor. **In what follows the distance has to stay fixed.**
- Now, modify the input frequency by looking approximately what happens when changing the frequency from 39 kHz to 43 kHz for instance. Note your observations.

The sound emitter presents what is called a band-with : it emits significantly between two cut-off frequencies f_1 and f_2 and its amplitude is maximum for a resonance frequency f_0 (see Figure

- **Estimate roughly** the value of f_0 for which the amplitude is maximal.

Measurents of the Amplitude-frequency response of the emitter

- Check that the distance between the emitter and the receptor has stayed fixed.
- Measure the Vpp (peak to peack) amplitude of the receptor signal for different frequencies f included between 39 kHz and 43kHz . To measure the amplitude of CH2 you can use the technic you want (with cursors or by reading directly the value on oscilloscope screen). The goal is to fill a tabular as below by taking more experimental points around the value of f_0. For instance start at 39 kHz and take a point every 0.2 kHz until 40.4 kHz. Then between 40.4 kHz and 41.6 kHz take a point every 0.1 kHz. From 41.6 to 43 kHz you can switch back to 0.2 kHz between each experimental point.

Frequency f (kHz)	39							43
Vpp of receptor (V)								

- Present the tabular in your notebook.
- Draw the graphic on millimeter paper Vpp=Vpp(f).
- Determine the value V_{PP}^{max} and the frequency f_0. Then draw a line that cut the graph at $V_{PP} = V_{PP}^{max}/\sqrt{2}$. Determine the cut-off frequencies f_1 and f_2.
- Plot the graph Vpp=Vpp(f) also with *Origin software.*

II.2) Measuring sound velocity by a measure of the wavelenght

We want to calculate the sound velocity v of the acoustic wave using the relation $v = \frac{\lambda}{T} = \lambda f$.
where f is the frequency of the wave and λ its wavelength. The frequency will be given by f_0. The goal of the manipulation is to measure the wavelength.

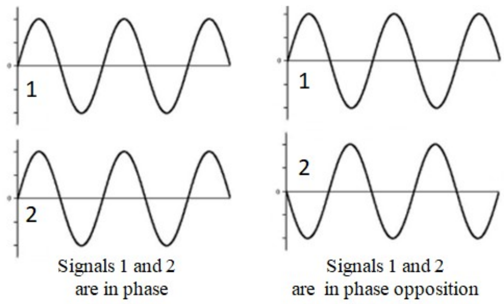

Figure 4.

- Set up the wave generator at frequency f_0 for which the signal amplitude is maximum.
- Put the receptor in front of the emitter and look what happens to the receptor signal when we increase the distance D between receptor and emitter.
- Find a position where signals are in phase and where signals are in phase opposition.

- Reput the receptor at a distance where the signals are in phase. Move back the receptor until the first distance where signals are again in phase : the distance between emitter and receptor is equal to the wavelenght λ.
- To measure λ more precisely move back the receptor to cover distance 10λ and measure it with the metallic ruler. Determine the value of λ.

Determination of the sound velocity

- Determine the sound velocity of the ultra-sound emitter.
- Compare to tabulated data $v_{sound} = 340$ m/s (at 15°C) by calculating a relative difference.
- Estimate the precision of your measurement.