# An Investigation on PVDF Piezoelectric Elements and Linear Array Transducers

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Ultrasonic waves are widely used in different application e.g. for sonar scanning in water and fetal imaging. It is also used for doing measurements on different materials to determine the thickness of the material or the velocity of sound inside it. The ultrasonic waves are produced and detected by using piezoelectric elements e.g. Polyvinylidene fluoride (PVDF)-film or Lead Zirconate Titanate (PZT)-elements. When voltage is applied between the electrodes of a piezoelectric element it vibrates leading to generation of ultrasonic waves. The process of generation of ultrasonic waves from a piezoelectric element is the following:

$$\text{Electrical pulse} \rightarrow \text{Mechanical vibration} \rightarrow \text{Ultrasonic wave generation}$$

The process of detection of ultrasonic waves in an ultrasonic transducer is the following:

$$\text{Reflected ultrasonic wave} \rightarrow \text{Mechanical vibration} \rightarrow \text{Electrical pulse}$$

In the thesis work, the aim has been to do measurements on different materials and then develop a linear array transducer based on the use of PVDF-films. Three different methods have been studied to do the measurements on different materials. The first method has been to use a commercial product (ultrasonic (US) key and software from Lecoeur), the second method has been to use the same US-key but in combination with MATLAB. The US-key is an ultrasonic device which is connected to ultrasonic transducer(s) to emit and detect ultrasonic waves. The software was used for displaying plots from the measurements. Finally, the third method involved the use of a generator and an oscilloscope. It has been found that the first and second methods did not work properly to make the linear array transducer because the US-key produced a noise artifact during measurements. The linear array transducer was made by using two industrial ultrasonic transducers of 1-MHz which were connected to the generator and three PVDF-films used as receivers and connected to the oscilloscope, see figure 1. The linear array transducer was built up to use it for examining a specific material. It was found that aluminum is the best material to be used to do the ultrasonic testing because of its low attenuation of the ultrasonic waves.

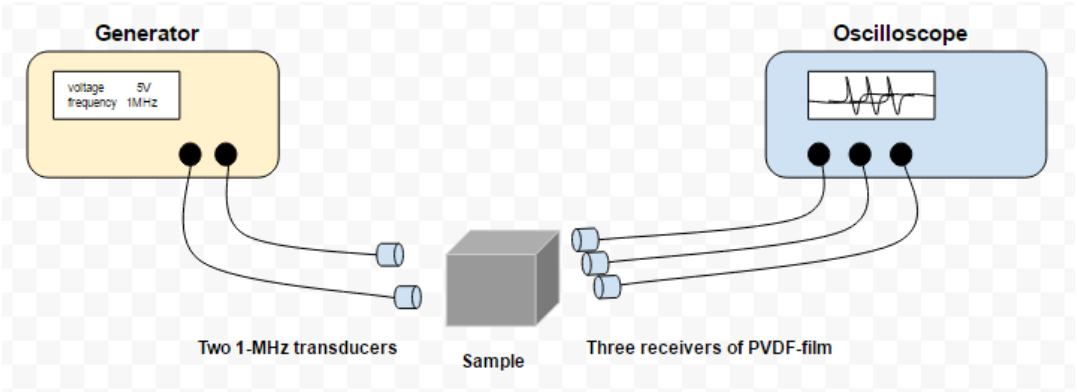


**Figure 1.** The layout of the linear array transducer with two emitters and three receivers by using generator and oscilloscope.

The provided images by PVDF-films were quite similar with the images from the industrial transducers and that gave a good sign that the PVDF-film is acceptable. The PVDF-film receivers in the linear array transducer where cut in two different shapes. The purpose of that is to determine the best shape of the PVDF-film for detecting of ultrasonic waves. The first shape was square and the second one was circular. The detection of ultrasonic waves is a little bit better in the circular PVDF-films and that is why most of the industrial transducers are in circular shape. The circular ones gave slightly higher detected amplitude than the square ones.

The conclusion of this thesis work is that the quality of ultrasonic images depends on three main factors. The first factor is the resonance frequency of the transducer, the second factor is type of the piezoelectric element and the third factor is the attenuation coefficient of the examined sample. It is important to use the right frequency when measuring on different samples. The thickness of the piezoelectric material determines the frequency of the transmitted ultrasonic waves. It is also important to use the right couplant when doing ultrasonic testing. The acoustic impedance of the couplant is important to be less than the acoustic impedance of the examined sample. Finally, it was found that PVDF.-film is better when it is used as emitter instead of receiver of ultrasonic waves.