Crosstalk between matrix transducer elements

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1. Project description and problem definition

In medical ultrasound imaging, a sound wave is transmitted by a piezoelectric transducer into the body, and the reflected waves are recorded by the same transducer to form an image of the tissue. To efficiently make images of a plane or a volume, a transducer usually consists of many individually controllable piezo-elements that are organized in a linear or matrix structure. In the latter case, transducers can easily count 10,000+ tiny elements. This, however, causes two electrical problems: first, due to the small size of the elements, their electrical impedance is high and the electrical signals will be severely attenuated by a connection cable, and second it is impossible to wire all individual elements to the ultrasound machine on which the signals are processed into an image. In the Transducer Lab of the Medical Imaging section at TU Delft, these problems are solved by mounting the tiny piezo-electric elements directly on a dedicated electronic chip (Application Specific Integrated Circuit - ASIC), on which the electrical signals from the elements are amplified and (partly) processed (see figure 1).

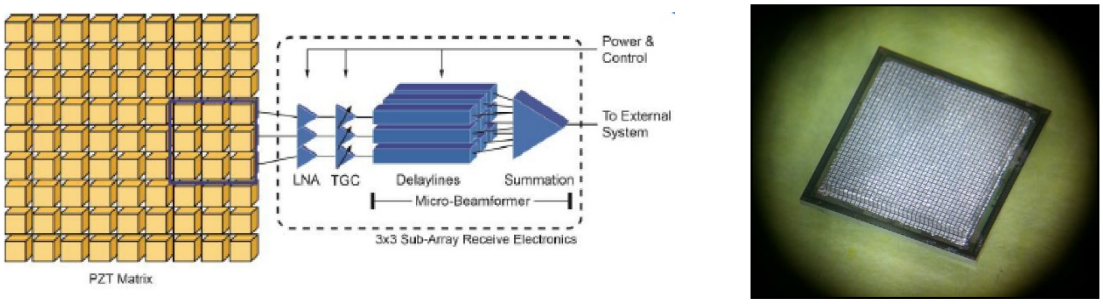

Figure 1: Schematic matrix array with local amplification and signal processing (left), prototype matrix array with 32 x 32 elements mounted on an ASIC (black square; right).

Although this approach solves the electrical problems, the approach of mounting piezo-electric elements onto a silicon layer causes acoustical problems that need to be solved. One problem is that the silicon mechanically couples the elements together. The makes that the elements show 'crosstalk' (i.e. they cannot vibrate independently). Currently, research is done on the reduction of crosstalk. However, elements are not only coupled through the silicon layer at the back, but also by the tissue medium at the front. The first coupling should be avoided, but the latter is inherent to the working principle of ultrasound imaging and cannot be reduced. The fundamental question is how low the total crosstalk can be made or, in other words, how large the crosstalk via the tissue medium is.

2. Objectives and research goals

The goal is to find how large the crosstalk via the tissue medium is.

3. Approach and activities

The physical answer is obtained by computing the *mutual impedances* between the transducer elements at the front (tissue) side. The mathematical tool for doing this is the *Rayleigh integral*.

- Literature reading.
- Numerical computation of mutual impedances by using the Rayleigh integral.
- Comparison with PZFlex simulations.
- Writing BSc. thesis.