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CROSS-TALK RESPONSE ANALYSIS ON A PIEZOELECTRIC ULTRASONIC MATRIX ARRAY

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The study of the cross-talk and its effects in the performance of a matrix array of piezoelectric elements is an important issue. This corresponds to the study of the cross mode of vibration of each one of the piezoelectric elements that form the ultrasonic array. The aim is to detect and measure the cross-talk that is generated for the cross mode of vibration. In order to accomplish this task, an array of 2x3 elements was designed and developed. This was constructed using 8 MHz piezoelectric ceramics. A number of configurations have been experimented, considering the excitation of an increasing number of elements, in order to detect and measure the propagation of wave interference. Initial results show the way cross-talk interferes the beam generated by the array, this causing attenuation of the main beam and other negative effects.

Introduction

The development of areas such as electronics and the transducers themselves [T.A. Whittingham, 1997], allowed the transducers evolve from simple to matrix. The transducers have a very versatile matrix and from the standpoint of operation and construction can be classified as:

- Linear
- Phase Matrix
- Annular

In Figure 1 are shown these arrays.

One of the common defects in the array is the mechanical coupling between the transducer elements as an element to be excited vibration can be transmitted by the passive element and gradually excites the other elements. Characterization of an array contains electric and acoustic measurements. The electrical measurement (impedance measurements), used to verify the similarity between the elements. The acoustic measurements have the same purpose and include the study of the waveform and frequency behavior in each of the elements.

In the design of an array as there are important parameters, the resonance frequency, the dimensions and geometry of the elements.

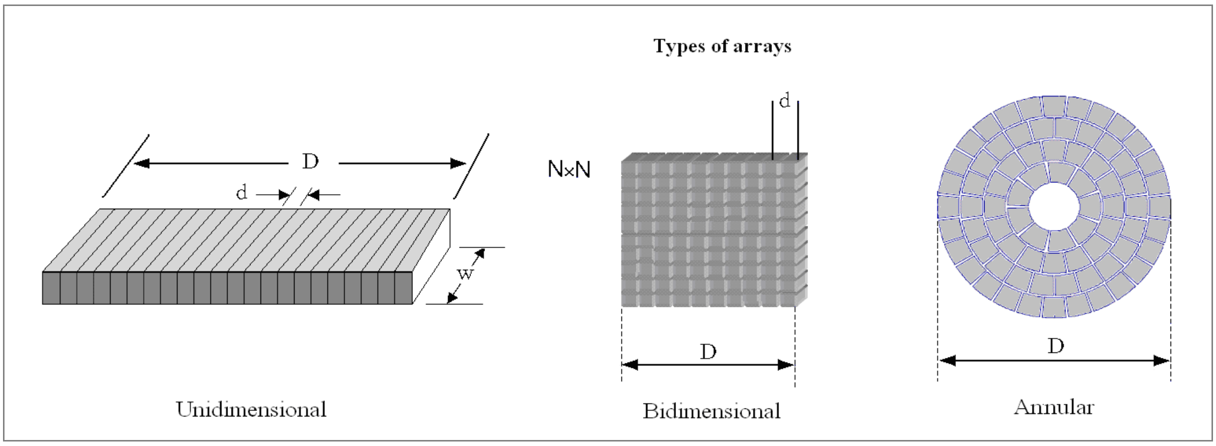

Figure 1. Types of arrays.

The cross-talk originates from the deficiency in the mechanical or electrical isolation between the elements. This phenomenon is particularly acute in phase matrices whose characteristic is the proximity between the elements. The performance of the transducers is affected by the cross-talk, which is basically the excitement of one element for contiguous elements [Kino e Desilets, 1979, Smith et al, 1979, Turnbull and Foster, 1992, Guess and Campbell, 1995, Frederick et al, 1990, Wojcik et al, 1996)].

In Figure 2, shows the various forms of interaction between the array elements that contribute to the phenomenon of cross-talk.

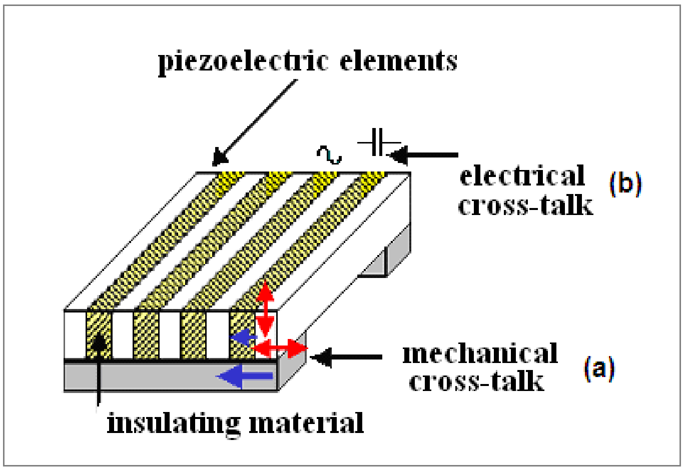

Figure 2. Various modes of coupling between array elements that contribute to the formation of cross-talk. (a) cross-talk mechanical acoustic wave propagation through the backing of the elements and the material that fills the separation between them. (b) cross-talk electric through capacitive coupling between elements and electrical connections as well as electromagnetic emission.

Methodology and development

The construction arrangement for measuring the shape of lateral vibration, was performed using a metal base, in which the piezoelectric ceramics are placed so that they can vibrate freely, the interest of the experiment is to quantify the cross-talk which originates the lateral mode of vibration of the ceramic, watching spreads to other piezoelectric elements, and how this signal affects the performance of the transducer as a whole. Figure 3 presents the base that was constructed for the experimental part as well as the dimensions of the base.

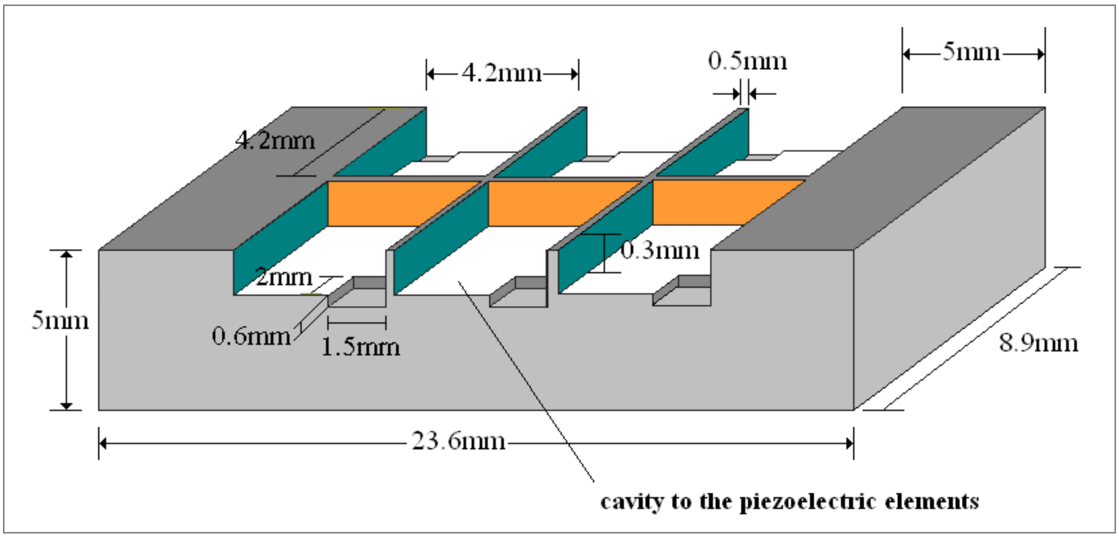

Figure 3. Diagram of the arrangement constructed for measuring crosstalk

To perform the study of cross-talk was decided to place piezoelectric ceramics, a separation distance is 1/4 λ. considering that λ is calculated as:

$$\lambda = \frac{c}{f} \tag{1}$$

Where:

c: speed of the ultrasonic propagation medium.
f: frequency.

For our particular case, we have the following values:
c = 1480 [m/s] water speed, and f = 8 [MHz]

$$\frac{\lambda}{4} = 46.25[\mu m] \tag{2}$$

Measurements were performed by driving the array with a pulse, as shown in Figure 4, this pulse was the same for each of the configurations used.

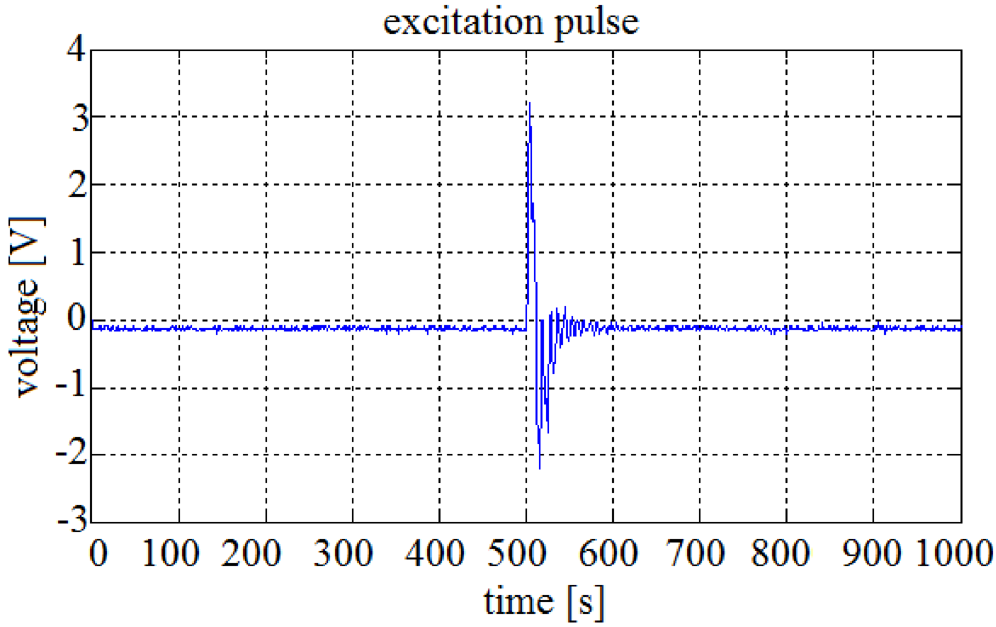

Figure 4. Pulse excitation to determine and quantify the presence of electrical crosstalk.

Once mounted the ceramics at the base, an electric pulse using a PULSER was applied to the PZT ceramics, then a measurement of the lateral vibrations that occur between the neighboring PZTceramics was made with a digital oscilloscope Tektronics (model DPO3000). Figure 5 shows the diagram of the experimental measurement of electrical Crosstalk [Sánchez, 2003].

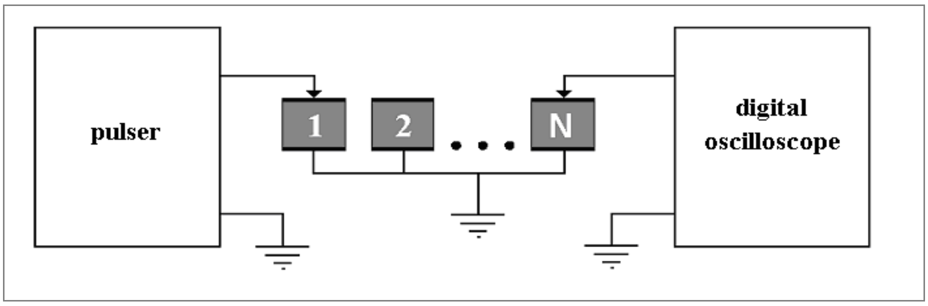

Figure 5. Diagram of the experimental measurement of electrical Crosstalk.

The set-up was build to observe the interaction in areas close to the ceramics and in areas further away from the ceramics. The gap between the ceramics remained constant, however the way they are mounted is not constant.

Results

Experimental measurements show the presence of interaction between the elements of the array, once these have been excited with an electric pulse. Figure 6 shows the graph of the pulse generated for the excitation of PZT ceramics. In a sequentially way the responses obtained in the different points of interest are presented.

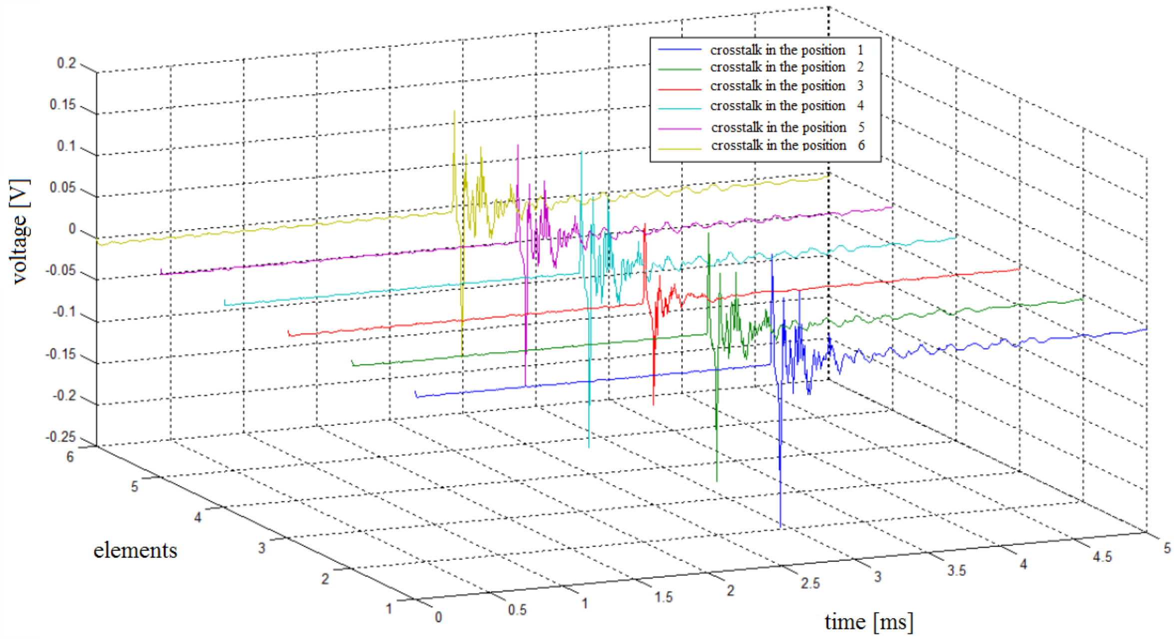

Figure 6. Response experimental arrangement of six ceramic square, shown as 3-D · to observe the effect of crosstalk.

As the effect of "cross-talk" is a signal input from all "undesirables" that are generated by the lateral vibration of the piezoelectric elements that make up the array. He proceeded to obtain the crosstalk signal generated in the experimental setup, showing the result in Figure 7, where it appears that this phenomenon is significant and can represent a problem in the performance of the array.

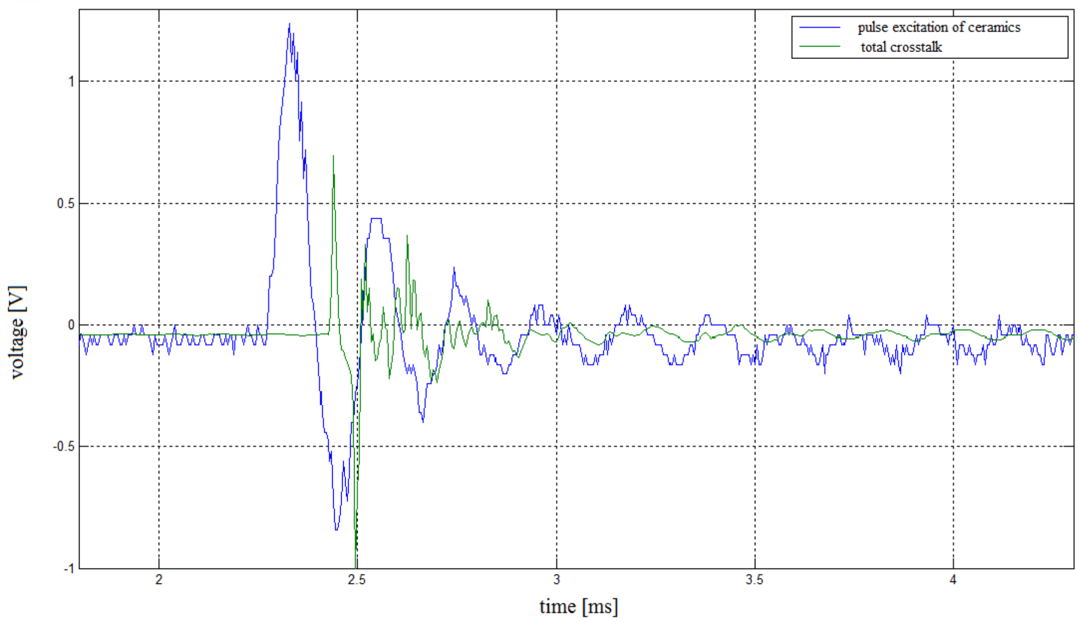

Figure 7. Pulse of the ceramic versus the total crosstalk

To verify that the crosstalk phenomenon affects the radiation pattern measurements were made of the radiation pattern of 3x2 matrix array of piezoelectric ceramics showing first the radiation pattern of the array without crosstalk and after the radiation pattern of the same matrix presenting the crosstalk phenomenon acting on it. In Figures 8 and 9 respectively show the radiation pattern with and without the presence of crosstalk.

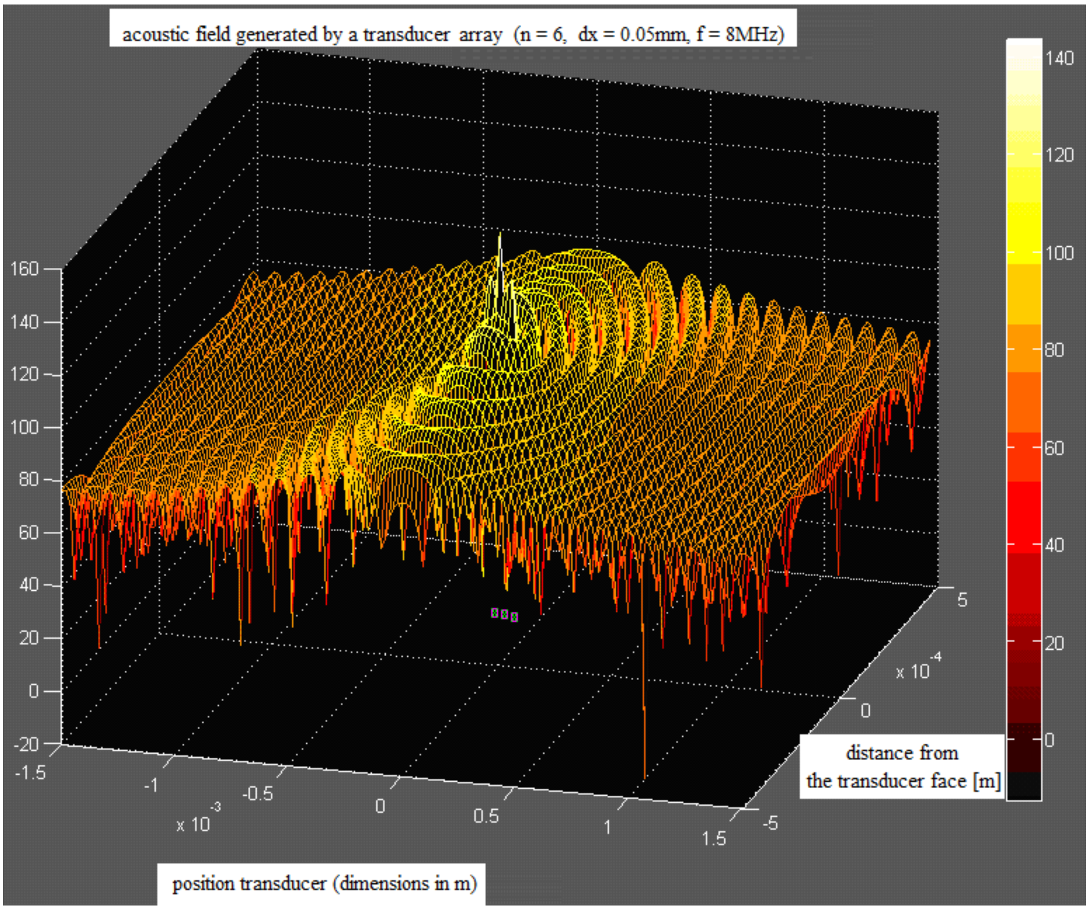

Figure 8. Radiation pattern of a 3x2 matrix array of piezoelectric elements. Without the presence of crosstalk.

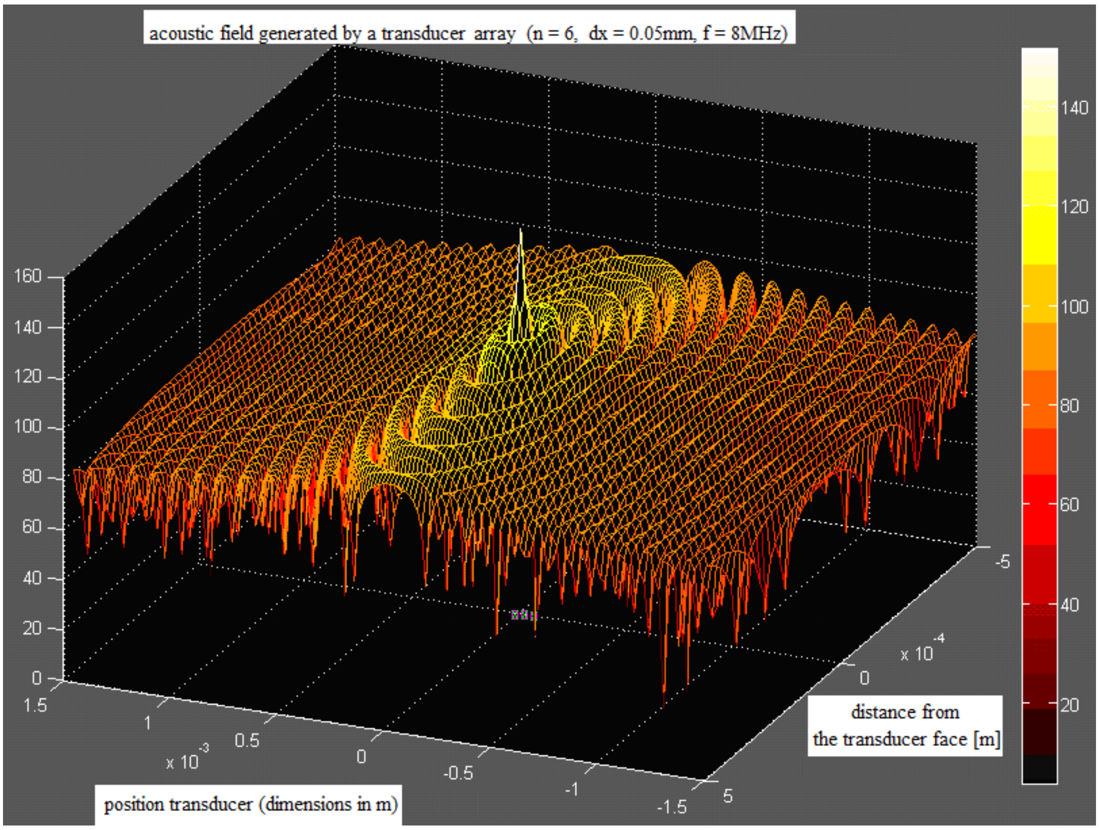

Figure 9. Radiation pattern of a 3x2 matrix array of piezoelectric elements. With the presence of crosstalk.

As mentioned the phenomenon of crosstalk comes in arrays of piezoelectric transducers, with an effect that manifests due to several factors, including:

- Dimension of the ceramic used for the construction of transducers.
- Distance between the piezoelectric elements.
- Frequency.

Which will affect the response of the array, here are the answers when you modify any of these parameters the radiation pattern will be affected in terms of phase or magnitude, and even in some cases modify both the phase and magnitude. This part was done by simulation.

The figure 10 presents an ideal case.

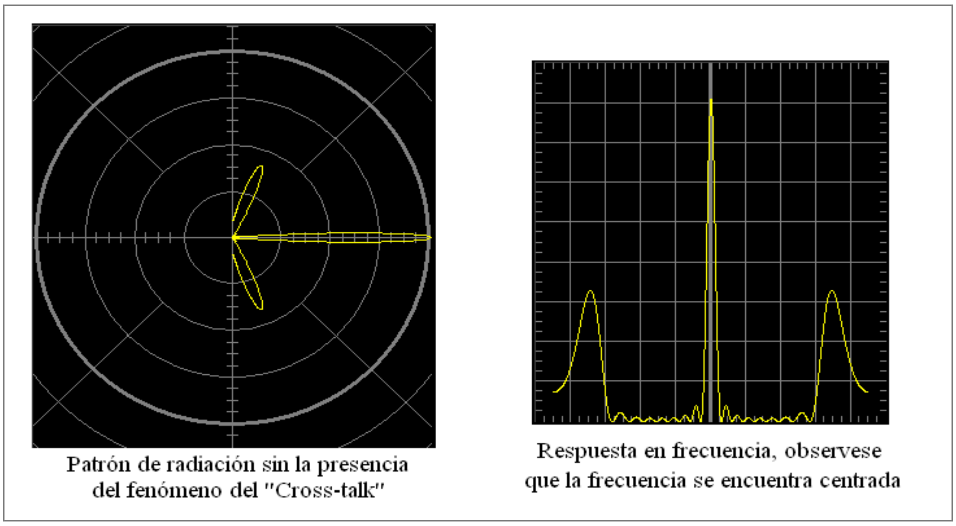

Figure 10. Radiation pattern and frequency response of a matrix array. Without the presence of crosstalk. Shows one form of radiation "normal".

The Figure 11, presents the variation of radiation patrol, with the presence of cross-talk and different distance between the piezoelectric elements.

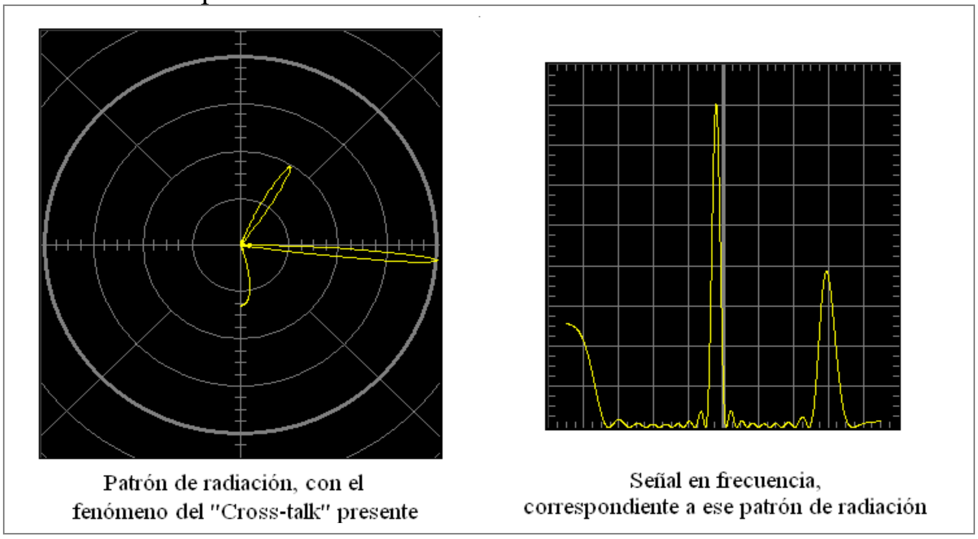

Figure 11. Radiation pattern and frequency response of a matrix array. With the presence of crosstalk. When the lateral mode of vibration interacts with the array elements when the distance between the elements is different.

CONCLUSIONS

It is possible to conclude that Crosstalk is present in all matrix arrays and in all cases can be seen that the material of the array influences the propagation of crosstalk, independently of the separation between the piezoelectric elements. The material used in the experiments gave interesting results, where the presence of the crosstalk phenomenon is present, based on these results it is worth to continue further work.

Acknowledgements

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