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Development Of 16 Element Linear Array Transducer

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ABSTRACT

Piezoelectric transducers are significant elements of many broadband ultrasonic systems, either pulse-echo or through-transmission, used for imaging and detection purposes. In ultrasonic broadband applications such as medical imaging, or non-destructive testing, piezoelectric transducers should generate/receive ultrasonic signals with good efficiency over a large frequency range. This implies the use of piezoelectric transducers with high sensitivity, broad bandwidth and short-duration impulse responses. High sensitivity provides large signal amplitudes which determine a good dynamic range for the system and the short duration of the received ultra-sonic signal provides a good axial resolution. This paper presents the simulation of linear array transducers for ultrasonic measurements.

Keywords--Ultrasonic, Linear array Transducer, medical imaging, Field-II GUI, TX/RX Fields, detected image, TX/RX Axial slice, TX/RX Axial slice.

For the period of the second half of 20th current century the medical imaging is grown through Ultrasound tool speedily. The part of novel technology is the use of computers to decide problems by simulating theoretical models (Numerical simulations) that has taken place alongside pure theory and experiment during the last few decades. These numerical simulations permit one to resolve problems that may not be accessible to direct experimental study or too complex for theoretical analysis. Computer simulations can link the gap between analysis and experiment **[1].**

These numerical simulations have emerged as a new branch in science and technology complementing both experiments and theory. A simulation can sometimes replace physical experiments, even though most often a simulation and an experiment are complementary. The results of scientific experiments are often explained by simulations and simulations are often calibrated by experiments. The experiments provide input for the simulations, which are viewed as experimenting with theoretical models. The feedback of numerical results into theoretical modeling and continues interaction with laboratory experiments and analytical theory makes computing a vital tool for science. Consequently the increased in computing power in both speed and storage has given computational electronics its significance. Improved computer capacity and the solution algorithms themselves, have a big outcome on the excellence of solution obtained. A numerical model can be used to understand measurements and observations enlarge existing analytical models into new parameter regimes and quantitatively test existing theories that can be done by comparing model predictions to experimental information.

The mutual weak point of both experiment and theory is cover up by the numerical simulations examination and experiment. A third dimension in ultrasonic measurements, of equivalent status and significance to experiment and analysis is nothing but the simulation determination **[1].** It has taken an everlasting place in every one aspect of ultrasonic measurements from basic research to engineering design.

A novel and potentially powerful tool is the computer experiment. One can resolve novel and uncertain aspects of usual process, by combining predictable theory, experiment and computer simulation **[1].** Such aspects could frequently neither have been understood nor reveled by analysis or experiments alone**.**

More than the last half century much development has been made in medical device technology. One particular medical technology that has enhanced speedily over the last 30 years is ultrasound. This advancement in technology however has brought with it the rapid obsolescence of system design. The accomplishment of modern electronics is built on the possibility to precisely predict system performance by the use of simulation tools. This model can be extended to components such as piezoelectric transducers attached to the electronics [2]. The ability to simulate both piezoelectric transducer and electronics together renders possible efficient optimizations at system level, i.e. minimizing size, price and power consumption [3].

The systems for images processing in the medical field are very important calling for new techniques, much more superior and performing than they used to be, in order to provide a acceptable analysis and diagnosis. Amongst the medical techniques using computer sciences, it can be mentioned: scintigraphy, echography, tomography, radiography, quantitative microscopy, nuclear magnetic resonance. Ultrasound, widely used in many areas of medicine, provides a secure and efficient means for diagnosis and therapy. When the medium becomes complex solving the wave propagation formula becomes virtually not possible. Modeling becomes much more complex inside the body because the ultrasound propagation speed is different for each tissue and it is known that tissues are not a homogeneous medium for ultrasound wave propagation [4]. Therefore, it is important to know how the ultrasound wave is generated and the ultrasound wave beam shaped.

II SPATIAL IMPULSE THEORY

The pressure field generated by the aperture is found by the Rayleigh integral [5]

$$p(\vec{r}_1\ ,\mathrm{t})=\frac{\rho_0}{2\pi}\int_s \frac{\partial v_n(\vec{r}_2.\mathrm{t}-\frac{|\vec{r}_1-\vec{r}_2|}{c})}{|\vec{r}_1-\vec{r}_2|}ds \qquad (1)$$

Where the field point is denoted by $\vec{r}_1$ and the aperture by $\vec{r}_2$, is the velocity normal to the transducer surface. Using the velocity potential, and assume that the surface velocity is uniform over the aperture making it independent of $\vec{r}_2$, then: where the field point is denoted by $\vec{r}_1$ and the aperture by $\vec{r}_2$, is the velocity normal to the transducer surface. Using the velocity potential, and assume that the surface velocity is uniform over the aperture making it independent of $\vec{r}_2$, then:

$$\Psi(\vec{r}_1\ ,\mathrm{t})=v_n(t)*\int_s \frac{\partial(\mathrm{t}-\frac{|\vec{r}_1-\vec{r}_2|}{c})}{2\pi|\vec{r}_1-\vec{r}_2|} \qquad (2)$$

Where * denotes convolution in time. The integral in this equation

$$h(\vec{r}_1\ ,\mathrm{t})=\int_s \frac{\partial(\mathrm{t}-\frac{|\vec{r}_1-\vec{r}_2|}{c})}{2\pi|\vec{r}_1-\vec{r}_2|}$$

(3)Represent the spatial impulse response. The continuous wave field can be found from the Fourier transform of

$$p(\vec{r}_1\ ,\mathrm{t})=\rho_0\frac{\partial v(t)}{\partial t}*h(\vec{r}_1\ ,\mathrm{t}) \qquad (4)$$

The impulse response includes the excitation convolved with both the transducers electro-mechanical impulse response in transmit and receive. The final signal for a collection of scatters is calculated as a linear sum over all signals from the different scatters [6-7].

III SIMULATION OF LINEAR ARRAY TRANSDUCER

The linear array is the fundamental type of multi-element transducer and it scans the region of interest by exciting the elements situated over the region. The field is focused on the region by introducing time delay in the excitation of the concerned individual elements, so initially concave beam is emitted. Here a Fig.1 shows general design format of 16 element linear array transducer having height, width and kerf of individual element are taken as 5 mm, 0.2 mm and 0.02 mm respectively. The transducers are situated at the center of the coordinate system. To achieve focal length of 30 mm from the center of transducer the electronic focusing is included.

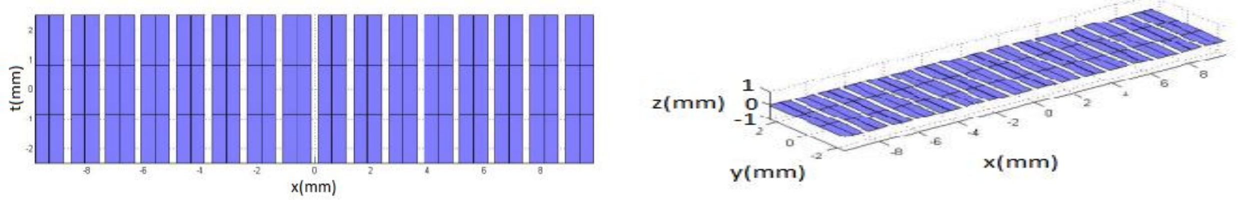


Fig. (1) Design format of linear array transducer (Height=5mm, Width=0.25mm, Kerf=0.02mm)

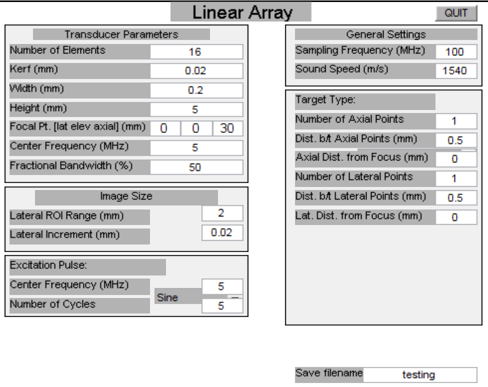
In this paper a linear array transducer of 16 elements is simulated using FIELD-II program with center frequencies 5MHz. For this specified linear array transducer, acoustic field generated is propagated through human body tissues and is observed at a focal distance i.e. (0, 0, 30)

IV RESULT AND DISCUSSION

The calculation of the impulse response is facilitated by projecting the field point onto the plane of the aperture. In this way, the problem became two-dimensional and the field point is given as a (x, y) coordinate set and a height z above the plane. The spatial impulse response is, thus, determined by the relative length of the part of the arc that intersects the aperture [8]. Thereby it is the crossing of the projected ultrasonic waves with the edges of the aperture that determines the spatial impulse responses as a function of time. In this paper by using FIELD-II program created a 16 element linear array transducer with center frequency fo = 5*MHz*. The speed of sound in tissue is c=*f*0 = 1540*m/s*, The sampling frequency used was *fs* = 100*MHz*. The elements had a width and height of 0.25mm and 5mm respectively. The focal-point was set to 30mm.

Table: 1 shows the parameters for 16 element array transducer, excitation pulse and medium used for this centre frequency (f_0) used is 5MHz. Figs. (a-m) shows; Element impulse response for 16 element array, TX Field image for 16 element array, TX Axial waveform for 16 element array, TX Lateral beam plot for 16 element array, TX/RX Field image for 16 element array, TX/RX Axial waveform for 16 element array, TX/RX Lateral beam plot for 16 element array, K- space TX/RX field image for 16 element array, K-space axial slice for 16 element array, K-space lateral slice for 16 element array, Detected image for 16 element array, Detected image axial slice for 16 element array and Detected image lateral slice for 16 element array.

image axial slice for 16 element array and Detected image lateral slice for 16 element array.



Linear Array

Transducer Parameters

Number of Elements	16
Kerf (mm)	0.02
Width (mm)	0.2
Height (mm)	5
Focal Pt. [lat elev axial] (mm)	0 0 30
Center Frequency (MHz)	5
Fractional Bandwidth (%)	50

Image Size

Lateral ROI Range (mm)	2
Lateral Increment (mm)	0.02

Excitation Pulse: Sine

Center Frequency (MHz)	5
Number of Cycles	5

General Settings

Sampling Frequency (MHz)	100
Sound Speed (m/s)	1540

Target Type:

Number of Axial Points	1
Dist. b/t Axial Points (mm)	0.5
Axial Dist. from Focus (mm)	0
Number of Lateral Points	1
Dist. b/t Lateral Points (mm)	0.5
Lat. Dist. from Focus (mm)	0

Save filename: testing

Table:1

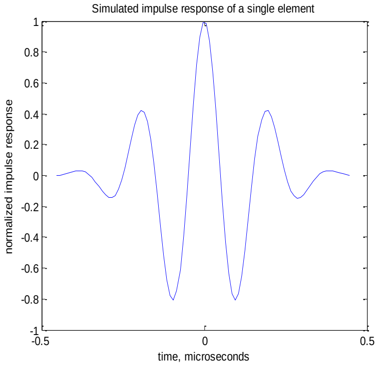


Fig. (a) Element impulse response

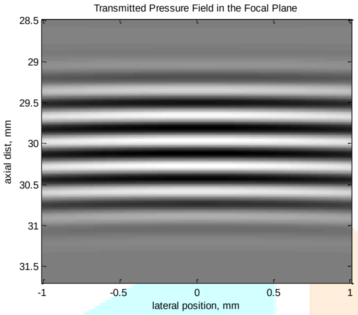


Fig. (b) TX Field image

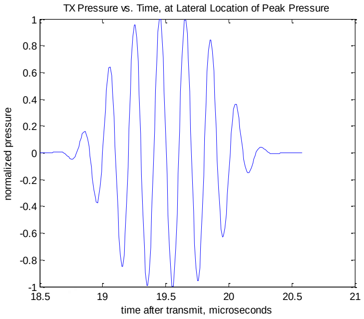


Fig. (c) TX Axial waveform

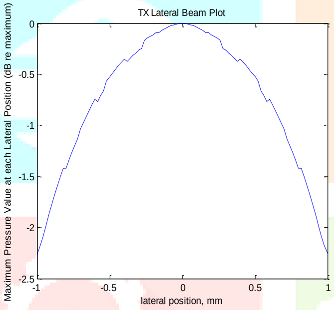


Fig. (d) TX Lateral beam-plot

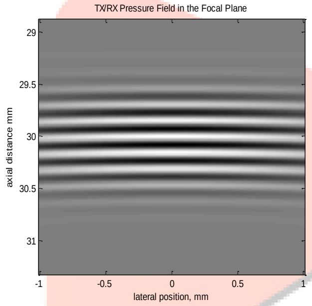


Fig. (e) TX/RX Field image

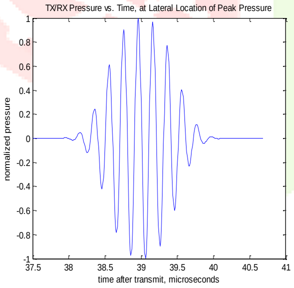


Fig. (f) TX/RX Axial waveform

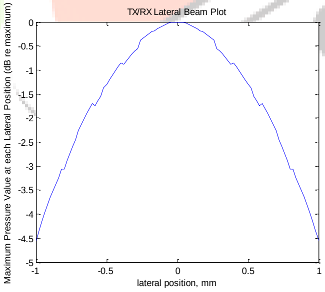


Fig. (g) TX/RX Lateral beam-plot

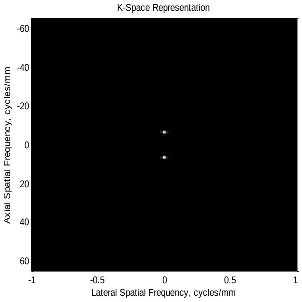


Fig. (h) K space TX/RX field image

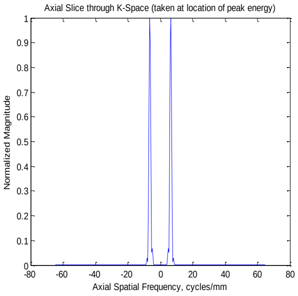


Fig. (i) K space axial slice

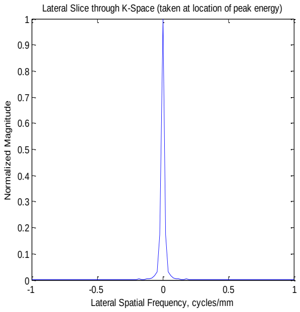


Fig. (j) K space lateral slice

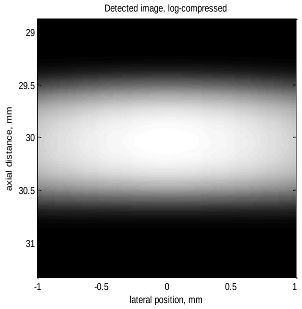


Fig. (k) Detected image

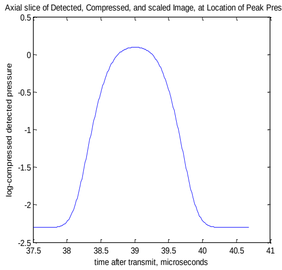


Fig. (l) Detected image axial slice

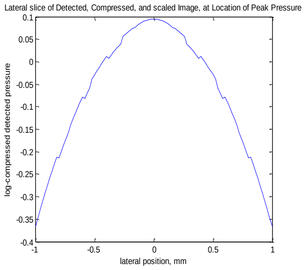


Fig. (m) Detected image lateral slice

V CONCLUSION

The paper attempts to present a coherent analysis of the focusing strategies for 2-D array transducer design and properties, based on linear acoustics. The delays on the individual transducer elements and their relative weight or apodization are changed continuously as a function of depth. This yields near perfect focused images for all depths. Similarly if number arrays in the transducer are increased then contrast of displayed image, has increased thus, benefitting the diagnostic importance of ultrasonic imaging.

References:

[1] Gandole, Y. B. (2012). Computer Modeling and Simulation of Ultrasonic System for Material Characterization. http://www.oalib.com/search? kw=Y.%20B.%20Gandole &searchField=authors.

[2] R. Krimholtz, D. Leedom, and G. Matthaci, "New equivalent circuits for elementary piezoelectric transducers," Electron. Lett. **6**, 398–399 ,1970

[3] T. R. Meeker, "Thickness mode piezoelectric transducers," Ultrasonics **10**, 26–36 ,1972.

[4] P. Marchal, F. Levarssort, L.-P. Tran-Huu-Hue, and M. Lethiecq, "Effects of acoustical properties of a lens on the pulse-echo response of a single element transducer," IEEE International Ultrasonics, Ferroelectrics, and Frequency Control Joint 50th Anniversary Conference, pp. 1651–1654,2004.

[5] Jensen, J.A, A New Approach to Calculating Spatial Impulse Responses, IEEE International Ultrasonic Symposium, Toronto, Canada, 1997

[6] P. Marchal, F. Levarssort, L.-P. Tran-Huu-Hue, and M. Lethiecq, "Effects of acoustical properties of a lens on the pulse-echo response of a single element transducer," IEEE International Ultrasonics, Ferroelectrics, and Frequency Control Joint 50th Anniversary Conference, pp. 1651–1654,2004.

[7] JENSEN, J.A., Field: A program for simulating ultrasound systems, 10th Nordic-Baltic Conference on Biomedical Imaging, in: *Medical & Biological Engineering & Computing*, 1996, **34**, Supplement 1, 351–353.

[8] Jensen, J.A., N.B. Svendsen, Simulation of advanced ultrasound systems using field II, Biomedical Imaging: Nano to Macro, 2004. IEEE International Symposiumon, 15-18 April 2004 Page(s):636–639 Vol.-1.