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Linear Array Transducer with Center Frequency 7.5 MHz

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ABSTRACT

Over the past decades, ultrasound imaging technology has satisfied outstanding improvement in obtaining significant diagnostic information from patients in a fast, noninvasive approach. Piezoelectric transducers are important elements of various broadband ultrasonic systems, either pulse-echo or through-transmission, used for imaging and detection purposes [1]. 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 8-element linear array transducers with center frequency 10 MHZ, using Field-II GUI program for ultrasonic measurements.

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

I INTRODUCTION

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 [2].

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 [3]. 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 [4].

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

$$h(\vec{r_1}\ ,\mathrm{t})=\int_s \frac{\partial(\mathrm{t}-\frac{|\vec{r_1}-\vec{r_2}|}{c})}{2\pi|\vec{r_1}-\vec{r_2}|} \qquad (3)$$

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 8 elements is simulated using FIELD-II program with center frequencies 7.5MHz. 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 32-element linear array transducer with center frequency fo = 10*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 8 element array transducer, excitation pulse and medium used, for this centre frequency (f_0) used is 7.5 MHz Figs. (a-m) shows; Element impulse response for 8 element array, TX Field image for 8 element array, TX Axial waveform for 8 element array, TX Lateral beam plot for 8 element array, TX/RX Field image for 8 element array, TX/RX Axial waveform for 8 element array, TX/RX Lateral beam plot for 8 element array, K- space TX/RX field image for 8 element array, K-space axial slice for 8 element array, K-space lateral slice for 8 element array, Detected image for 8 element array, Detected image axial slice for 8 element array and Detected image lateral slice for 8 element array.

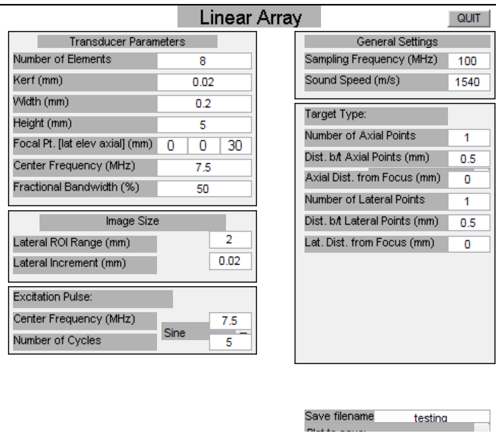

Table: 1

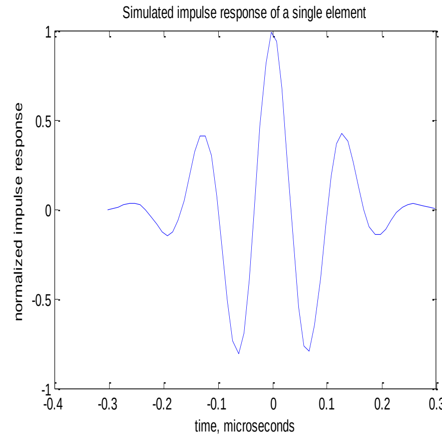

Fig. (a) Element impulse response

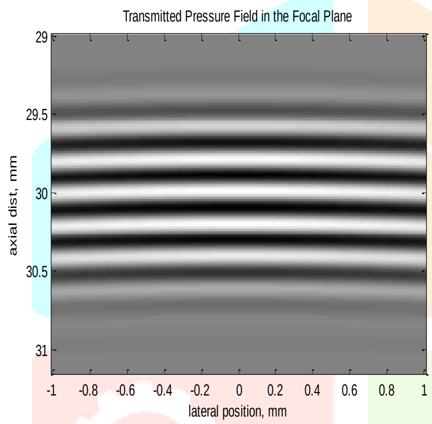

Fig. (b) TX Field image

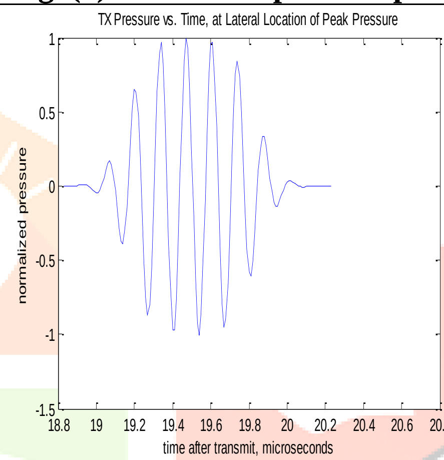

Fig. (c) TX Axial waveform

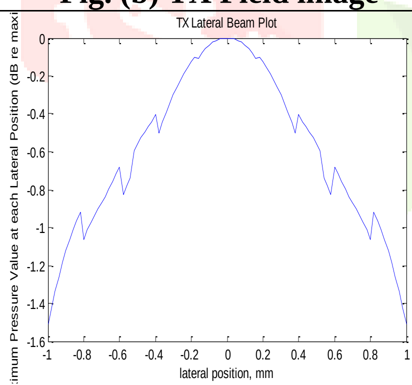

Fig. (d) TX Lateral beam plot

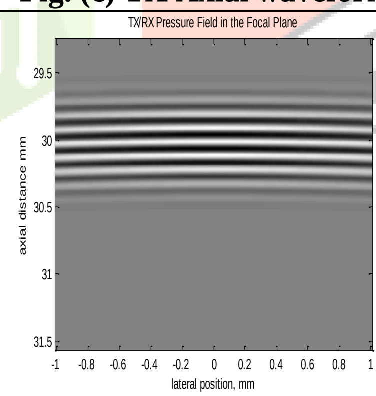

Fig. (e) TX/RX Field image

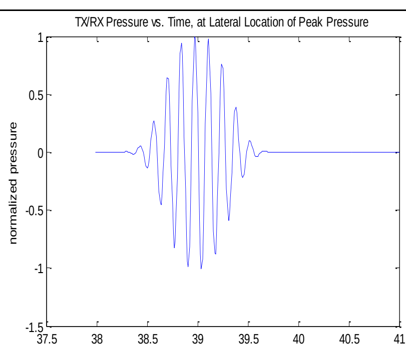

Fig. (f) TX/RX Axial waveform

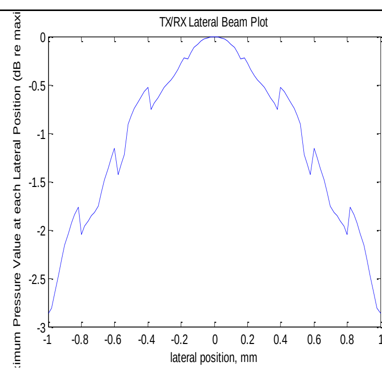

Fig. (g) TX/RX Lateral beam plot

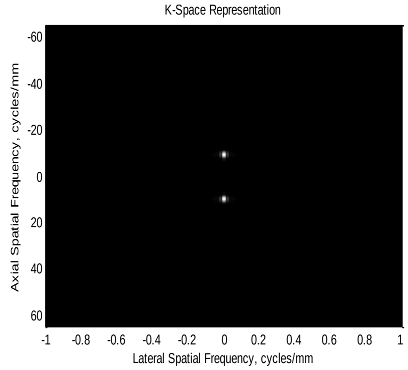

Fig. (h) K space TX/RX field image

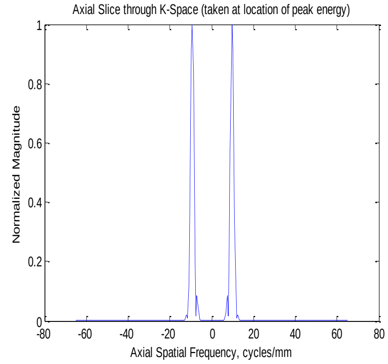

Fig. (i) K space axial slice

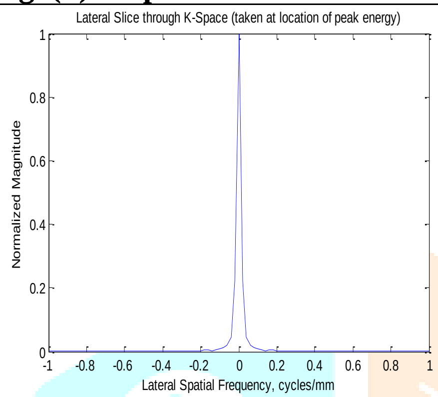

Fig. (j) K space lateral slice

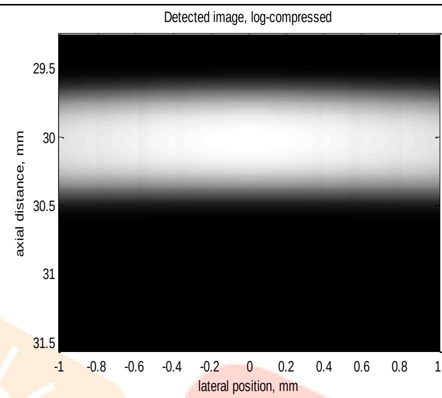

Fig. (k) Detected image

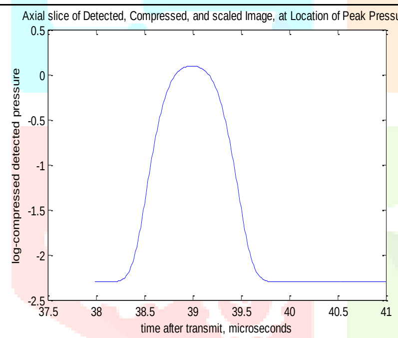

Fig. (l) Detected image axial slice

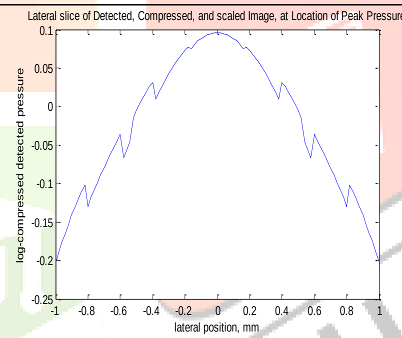

Fig. (m) Detected image lateral slice

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 and has increased the contrast in the displayed image, thus, benefitting the diagnostic importance of ultrasonic imaging. If the center frequency and number of elements in transducer is increased then contrast in the detected image is increased, this also increases the diagnostic status of ultrasonic imaging

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