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ReviewStudy of Linear Arrays Transducers with Center Frequency 5 MHz

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ABSTRACT

Ultrasonic arrays are used in numerous applications including medical imaging. In this specific case is imperative to achieve precise information about the magnitude and position of the peak pressure, intensity, detected image and various pressure fields produced by the transducerprobe. The systems for image processing in the medical field are very important calling for new techniques much more advanced and performing than they used to be, in order to provide a correct analysis and diagnosis. This paper presents the review study oflinear arrays Transducers with center frequency 5MHz for ultrasonic measurements.

KEY WORDS: Ultrasonic, Linear array, Detected Image, Field-II GUI, TX/RX Pressure field, medical imaging,

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].

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.The capability to simulate both piezoelectric transducer and electronics jointly renders possible efficient optimizations at system level, i.e. minimizing size, price and power consumption [2].

II. SPATIAL IMPULSE THEORY

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

$$p(\vec{r_1},t)=\frac{\rho_0}{2\pi}\int_s \frac{\partial v_n(\vec{r_2}.t-\frac{|\vec{r_1}-\vec{r_2}|}{c})}{|\vec{r_1}-\vec{r_2}|}ds \qquad (1)$$

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:

$$\Psi(\vec{r_1},t)=v_n(t)*\int_s \frac{\partial(t-\frac{|\vec{r_1}-\vec{r_2}|}{c})}{2\pi|\vec{r_1}-\vec{r_2}|} \qquad (2)$$

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

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

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

$$p(\vec{r_1},t)=\rho_0\frac{\partial v(t)}{\partial t}*h(\vec{r_1},t) \qquad (4)$$

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. 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.

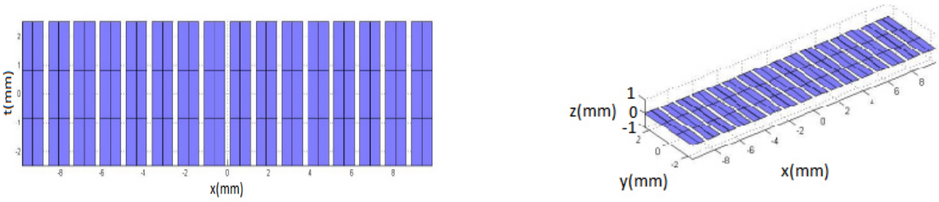

Fig. (1) Design format of linear array transducer (Height=5mm, Width=0.25mm, Kerf=0.02mm)

In this paper a linear array transducer of 4-elements and 8-elements is simulated by using FIELD-II GUI program with center frequencies 5MHz. For these specified linear array transducers, 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]. There by 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 4-element and 8-element linear array transducer using field -II GUI with center frequency (fo) = 5MHz. The speed of sound in tissue is c=$f0$ = 1540m/s, The sampling frequency used was fs = 100MHz. The elements had a width and height of 0.25mm and 5mm respectively. The focal-point was set to 30mm.

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Table: 1 shows the parameters for 4 element array transducers and **Table: 2** shows the parameters for 4 element array transducer, excitation pulse and medium used for this center frequency (f_0) used is 5MHz.

Figs. (a1-m1) shows the parameters for 4 element array transducer and figs (a2-m2) shows the parameters for 8 element array transducers

Fig a1& a2	Element impulse response for 4 and 8 element arrays.
Fig b1& b2	TX Field image 4 and 8 element arrays.
Fig c1&c2	TX Axial waveform 4 and 8 element arrays.
Fig d1& d2	TX Lateral beam plot 4 and 8 element arrays.
Fig e1& e2	TX/RX Field image 4 and 8 element arrays.
Fig f1& f2	TX/RX Axial waveform 4 and 8 element arrays.
Fig g1& g2	TX/RX Lateral beam plot 4 and 8 element arrays.
Fig h1& h2	K- space TX/RX field image 4 and 8 element arrays.
Fig i1& i2	K-space axial slice 4 and 8 element arrays.
Fig j1& j2	K-space lateral slice 4 and 8 element arrays.
Fig k1& k2	Detected image for 4 and 8 element arrays.
Fig l1& l2	Detected image axial slice 4 and 8 element arrays.
Fig m1&m2	Detected image lateral slice 4 and 8 element arrays.

Table: 1

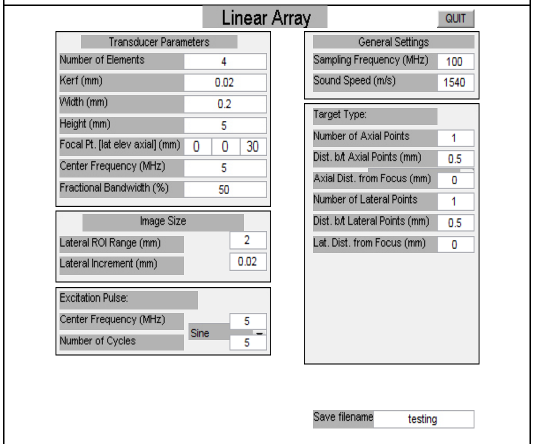
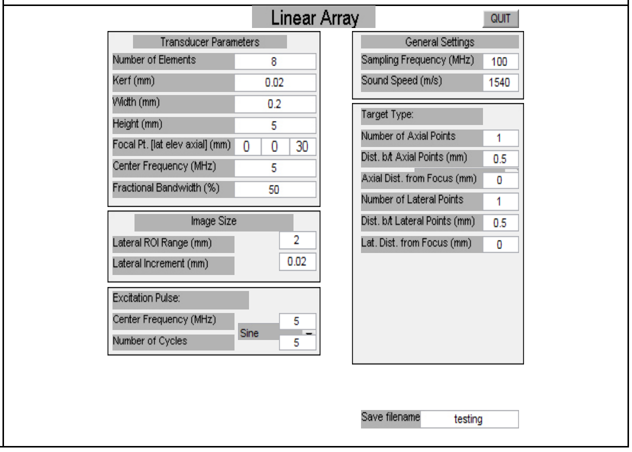


Table: 2



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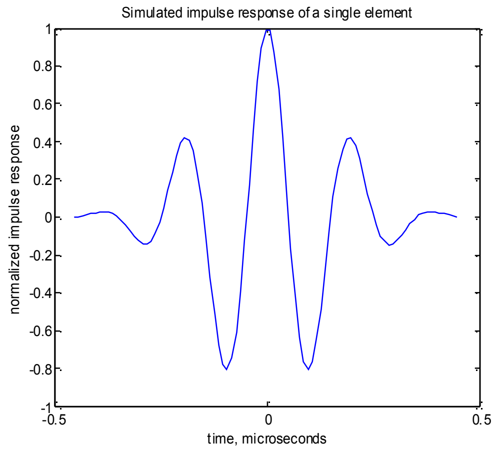

Fig. (a1) Element impulse response

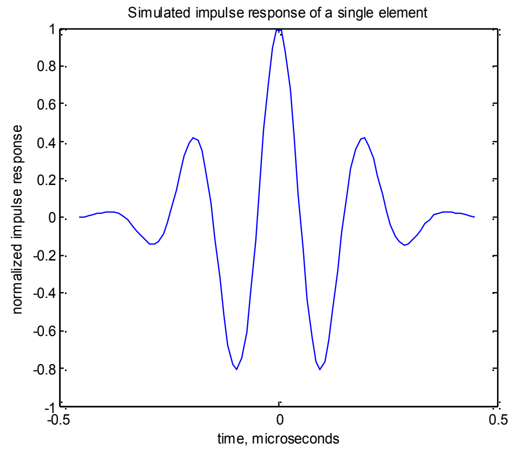

Fig. (a2) Element impulse response

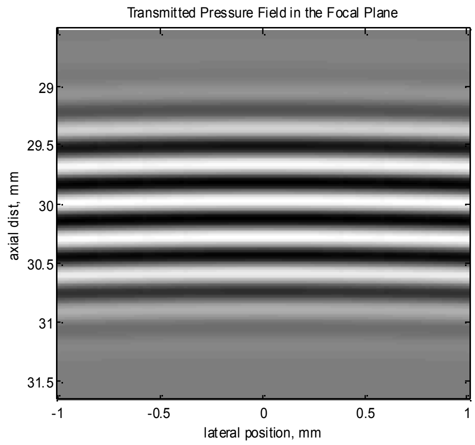

Fig.(b1) TX Field image

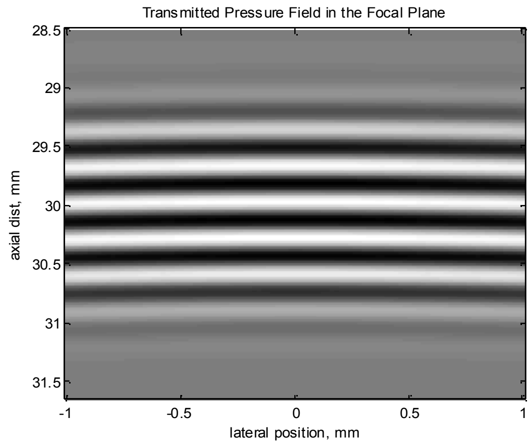

Fig. (b2) TX Field image

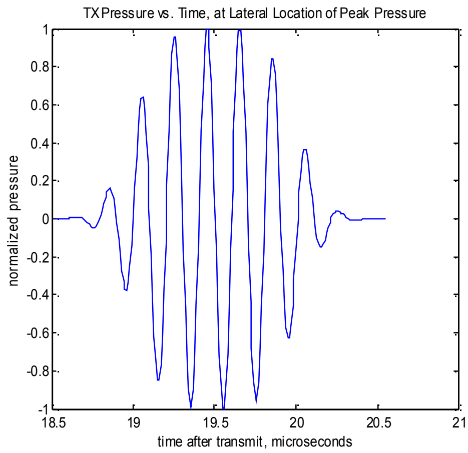

Fig. (c1) TX Axial waveform

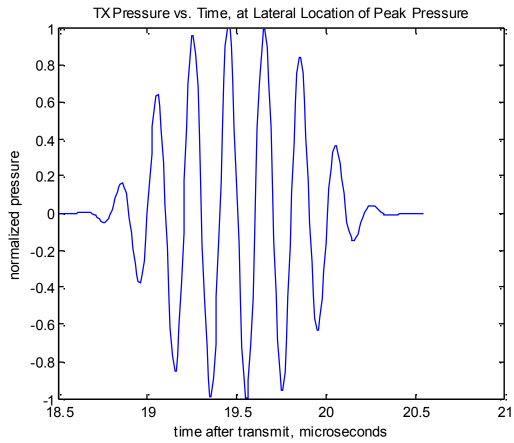

Fig. (c2) TX Axial waveform

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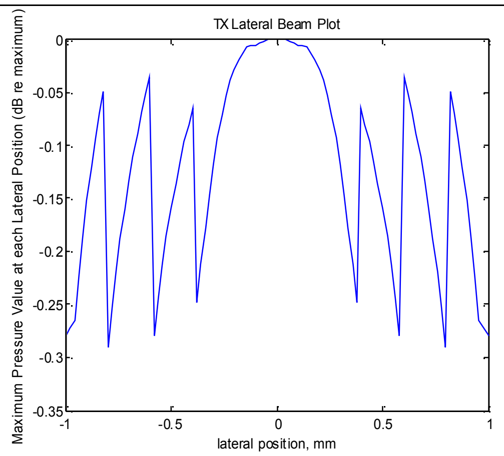

Fig. (d1) TX Lateral beam-plot

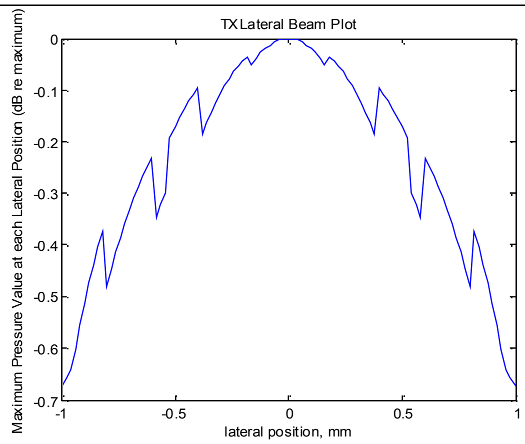

Fig. (d2) TX Lateral beam-plot

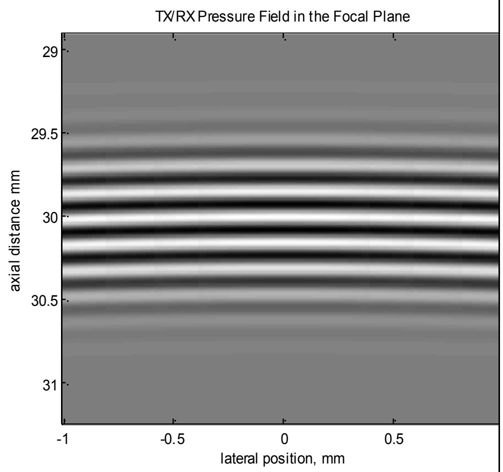

Fig. (e1) TX/RX Field image

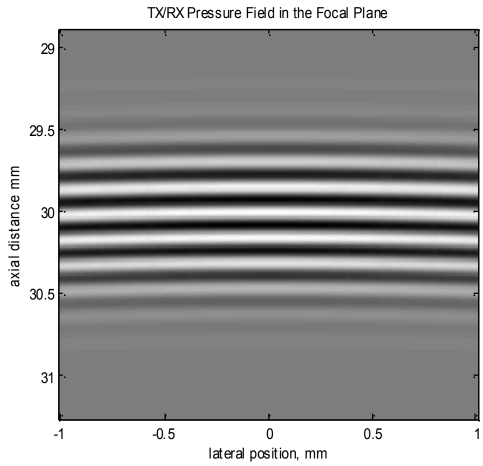

Fig. (e2) TX/RX Field image

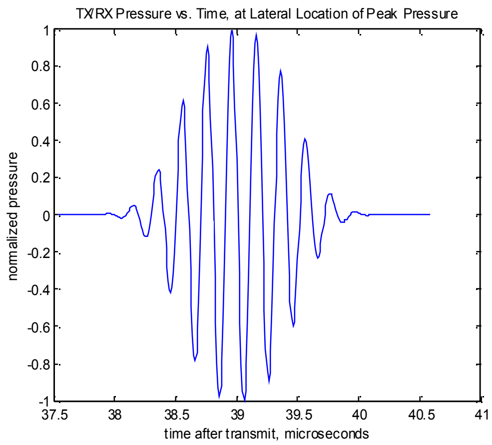

Fig. (f1) TX/RX Axial waveform

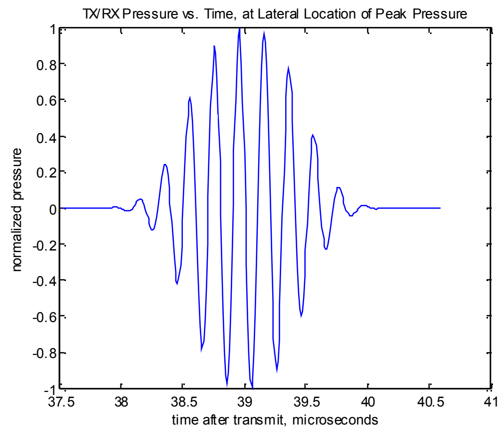

Fig. (f2) TX/RX Axial waveform

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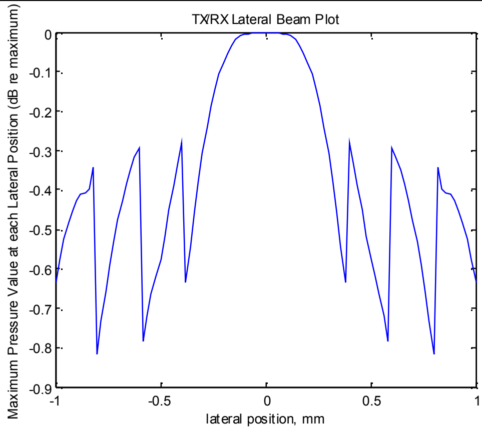

Fig. (g1) TX/RX Lateral beam-plot

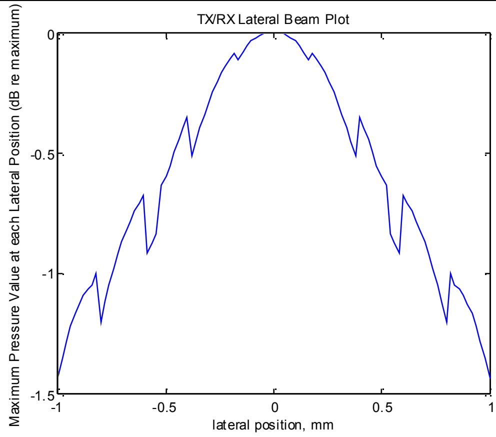

Fig. (g2) TX/RX Lateral beam-plot

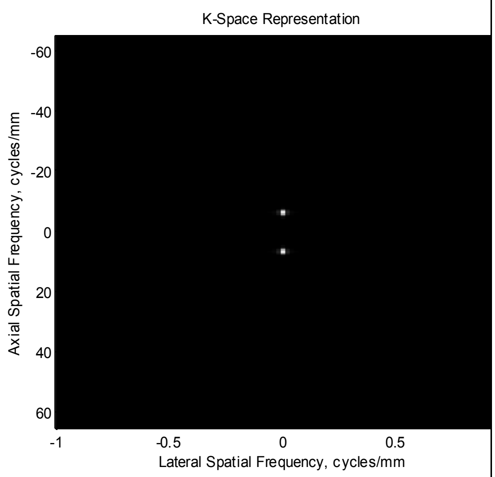

Fig. (h1) K space TX/RX field image

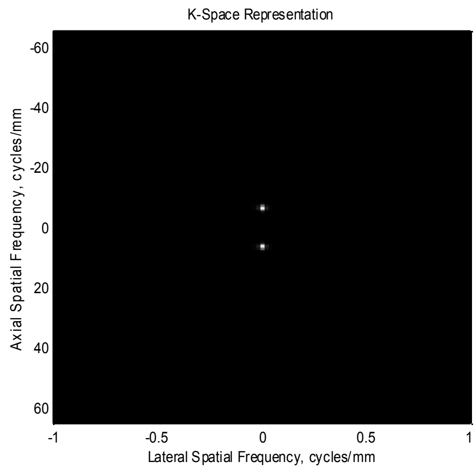

Fig. (h2) K space TX/RX Field image

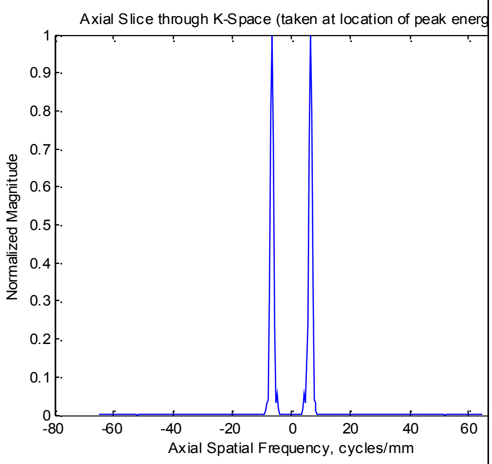

Fig. (i1) K space axial slice

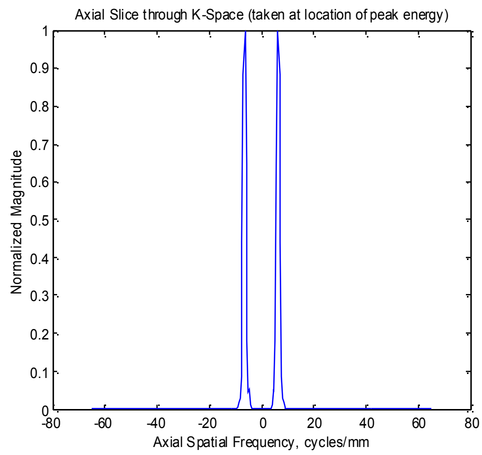

Fig. (I2) K space axial slice

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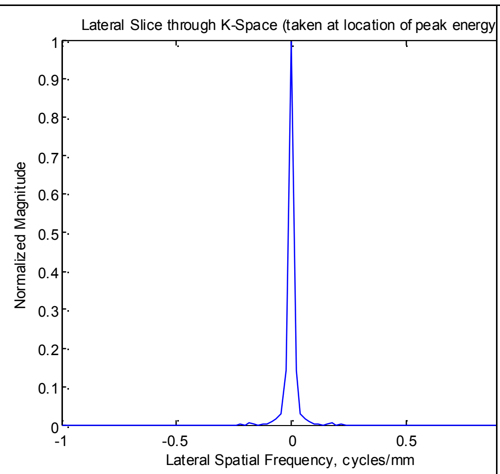

Fig. (j1) K space lateral slice

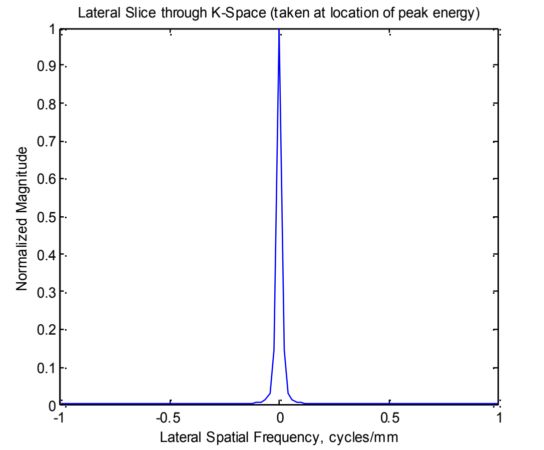

Fig. (j2) K space lateral slice

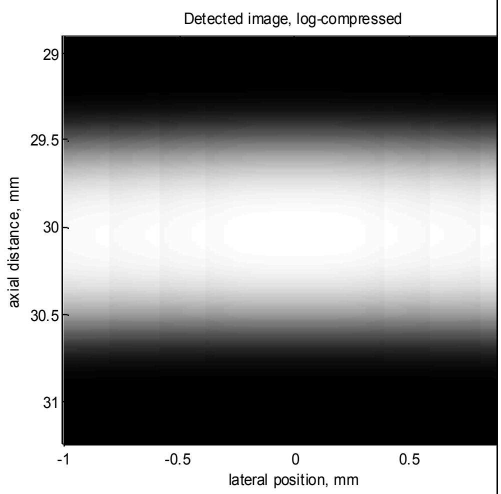

Fig. (k1) Detected image

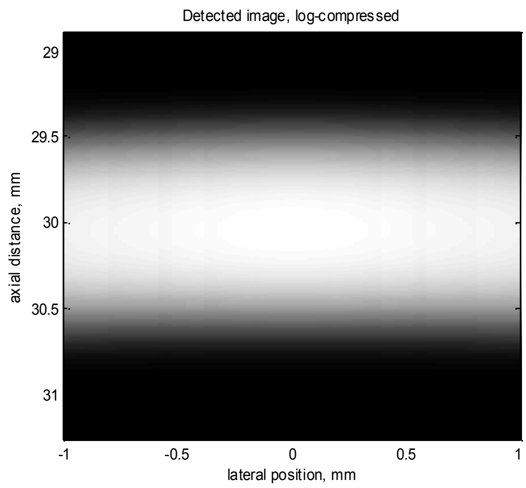

Fig. (k2) Detected image

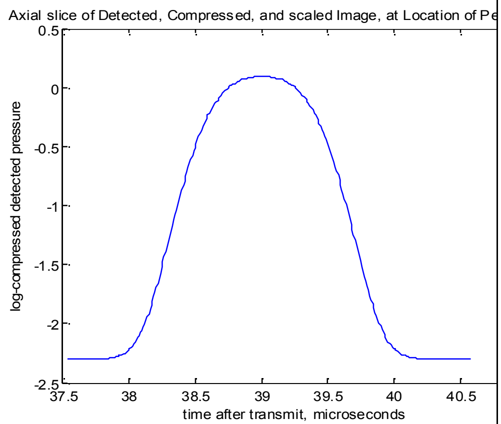

Fig. (l1) Detected image axial slice

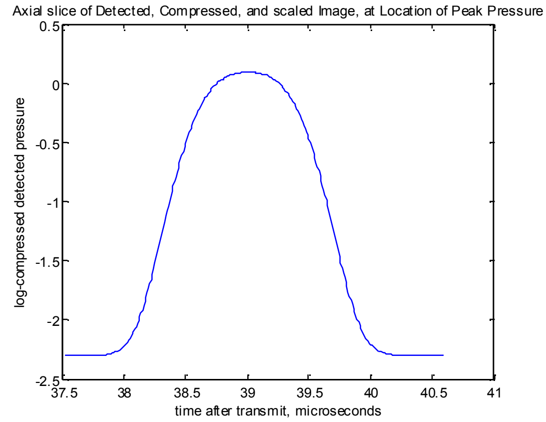

Fig. (l2) Detected image axial slice

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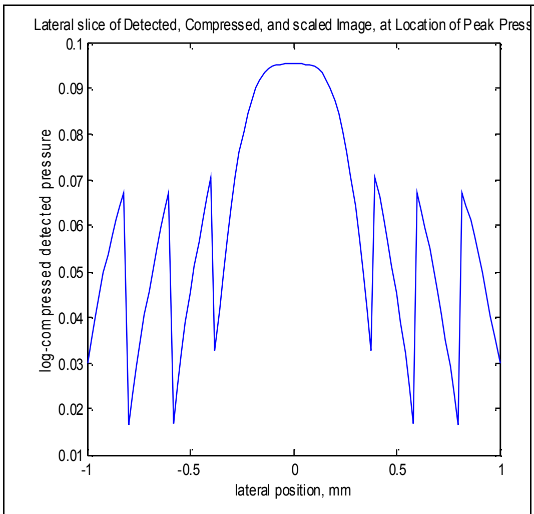

Fig.(m1) Detected image lateral slice

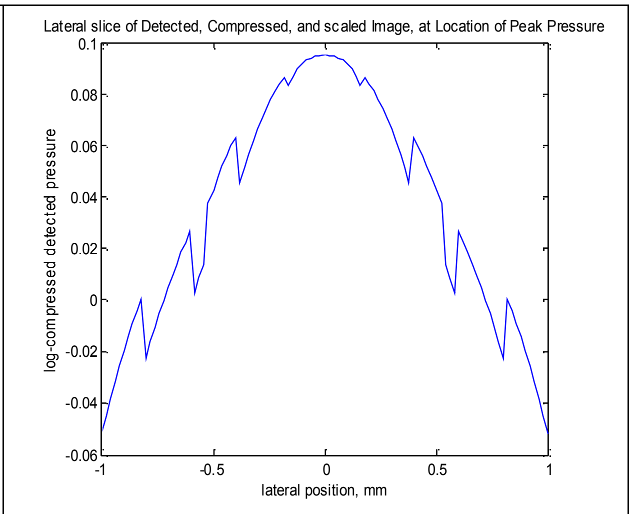

Fig. (m2) Detected image Lateral slice

V. CONCLUSION

The paper attempts to present review and comparative study of linear array transducers. It presents 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 (Image detected for 8 element array transducer is clearer than 4 element array), this also increases the diagnostic status of ultrasonic imaging

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