BEAM STEERING OF ELECTRICALLY SEGMENTED PIEZO-CERAMIC ULTRASONIC TRANSDUCERS USING NORMAL MODE COUPLING

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SAN DIEGO

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A dissertation submitted in partial satisfaction of the requirements for the degree of Doctor of Philosophy in Electrical Engineering (Applied Physics)

by

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ABSTRACT OF THE DISSERTATION

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It is well known that normal mode coupling in large diameter piezoelectric plates causes serious difficulties when attempting to operate over wide frequency bands. As a consequence transducers are commonly constructed as a mosaic of elemental resonators, each of which has a predominant single mode of mechanical oscillation at the frequency of interest. Such transducer arrays may be electrically steered to angles other than normal by applying different phases of driving

voltages to different elements. A continuous plate can also be used to steer a radiated beam using normal mode coupling in a narrow band system. The technique is to adjust the frequency of the driving voltage to match the travelling wave velocity of the normal mode which possesses the desired spatial phase relationship across the face of the plate. If the electrodes of a continuous piezoelectric plate are segmented so that regions of the plate can be driven with different phases, adjacent normal modes corresponding to a sine-cosine spatial phasing can be preferentially excited to generate a travelling wave. A true travelling wave will suppress the strong mirror lobe that would exist if a standing wave were excited. The velocity of the wave will be frequency dependent and the wave number can be controlled to generate a steered radiated beam.

In this research the theory of normal mode steering will be developed, the dispersion curve will be derived so the travelling wave velocities can be evaluated, and the effect of the mirror lobe due to the reflection from the edge boundary will be analyzed. Finally, the theory will then be verified by measurements on an experimental normal mode transducer which will be compared with a companion staved or mechanically segmented transducer.

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