A REVIEW OF IMPULSE RESPONSE METHODS TO EVALUATE ACOUSTIC TRANSIENT AND HARMONIC RADIATION FROM ARRAYS

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The present paper reviews the development of impulse response and convolution integral methods to evaluate the acoustic transient and harmonic radiation from arrays of projectors which are excited by electrical excitations of arbitrary bandwidth. In order to address the subject, the paper is subdivided into a review of recent contributions in the following areas:

i. impulse response methods of evaluating the acoustic fields resulting from specified temporal wide bandwidth velocities of the radiation surfaces of planar projectors,

ii. impulse response methods of evaluating acoustic interactions among transducers with specified temporal wide bandwidth velocities of the radiating surfaces, and

iii. impulse response methods of evaluating the wide bandwidth velocities of the radiating surfaces for an array of projectors which are acoustically coupled and electrically excited.

The development of the impulse response method for each of the aforementioned areas is presented along with pertinent numerical results which illustrate acoustic transient radiation and array phenomena of importance.

The impulse response method of analyzing acoustic near and far field transient and harmonic radiation from vibrating pistons of arbitrary shape is first reviewed. The mathematical development of the impulse response method is presented via the use of a time dependent Green's function solution to an initial boundary value problem. It is shown that the time dependent field

pressures which result from the specified time dependent velocity of a vibrator can be expressed as a convolution of the velocity with a spatially dependent impulse response. In addition, the frequency dependence of the harmonic pressure field resulting from a harmonic velocity is shown to be simply related to the Fourier transform of the spatially dependent impulse response.

Several general characteristics of the acoustic field which result from the pulsed excitation of baffled pistons of arbitrary shape are discussed. Numerical results are then presented to illustrate the characteristics of the impulse response and the characteristics of the acoustic near and far field pressures which result from the pulsed velocity of elliptical, circular and rectangular pistons which are excited by wide bandwidth excitations.

The extension of the impulse response method to evaluate the acoustic wide bandwidth interaction forces among elements of arbitrary shape and spacing in an array is then addressed. It is shown that the time dependent force, which acts on an element in an array due to the time dependent velocity of an adjacent element, can also be expressed as a convolution of the velocity with a force impulse response. It is further shown that the Fourier transform of the force impulse response corresponding to two elements is directly related to the familiar mutual radiation impedance between the elements.

The time domain characteristics of the force impulse responses are then presented and discussed for pistons of arbitrary shape. Since the mutual radiation impedances are simply related to the Fourier transform of the generalized impulse response, many of the characteristics of the mutual radiation impedance are evident from the force impulse responses via the use of elementary Fourier transform relationships. In order to illustrate the foregoing comments, numerical results are presented for the force impulse responses and mutual radiation impedance between circular pistons with various spacings.

The extension of the impulse response method is then presented to evaluate the velocities of the radiating surfaces for a planar array of projectors which are acoustically coupled and electrically excited. A general multi-input/multi-output model of the array which is readily applicable for transient analysis is presented and discussed. It is shown that for the case of harmonic electrical excitations of the projectors, the harmonic velocities can be obtained from the model via the well known solution of a matrix equation.

Several approaches to evaluate the time dependent velocities of the projectors resulting from wide bandwidth electrical excitations are presented. In particular, it is noted that the time dependent velocities can be described by a set of time-domain coupled convolution integral equations which include the previously noted force impulse responses. Since the equations can be readily solved in the time domain, the method offers a means by which the transient response and associated limitations of arrays can be evaluated. In order to illustrate typical characteristics of the transient response of elements in an array, numerical results are presented for several cases of interest and the results are discussed.