# CHAPTER 5

## SIMULATION PACKAGE FOR ARRAY DESIGN

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Chapter 5

SIMULATION PACKAGE FOR ARRAY DESIGN

5.1 INTRODUCTION

The transmitting and receiving characteristics of transducer arrays depend on various factors like its geometry, number of elements, source strength, relative phases of the elements etc. Array with narrow main beam and low sidelobes is desirable for a variety of applications. But these are conflicting requirements. One of the requirements can be achieved only at the cost of the other. It is the designer's choice to select the parameters depending on the nature of application.

The basic assumptions made for the theoretical predictions of the performance of an array may not be exactly correct in practical implementation, due to the electrical and mechanical limitations. Due to this, the measured array parameters are found to differ from the theoretically formulated ones. Hence, an array design package has been developed and
presented in this chapter for predicting the optimum array, based on the requirements of the user, taking into account the inferences and conclusions arrived at from the studies on acoustic interaction effect experienced in different array systems.

5.2 SOFTWARE PACKAGE

In order to reduce the computational burden and to make the package more user friendly, the array design software has been split into different modules, each module carrying out a specific task. The major sub-programs will help in:

(a) array shape selection
(b) element shape selection
(c) reading in and modification of input parameters
(d) design calculations and
(e) display of results.

The modules are written in such a way that the user is prompted for all the input parameters, whenever a
choice exists, and a menu is displayed showing the various alternatives [100-102]. The flow chart which facilitates the array design is shown in Figure 5.1.

5.2.1 Module I: Array Shape Selection

Interaction effect acting on an array is mainly depending on its array geometry. This effect is much pronounced in closely packed arrays and are greater for planar arrays than curved ones. For example, in a large planar array, the combined interaction from the distant transducer elements can be smaller when compared to that from the nearest transducers, while it might be negligible in a curved array [34].

This module allows the user to choose the required shape of the array from various alternatives. Initially, a menu is displayed, listing the various alternatives and prompting for the user's choice. Once the choice is made, the relevant parameters of the array are loaded into the system.
Fig. 5.1: Flow chart accomplishing the array design
The shapes available in this package are:

i) linear array

ii) planar array—circular/square/rectangular radiating aperture.

5.2.2 Module II: Element Shape Selection

From equation (2.4), it is clear that the magnitude of the interaction force is a function of the element shape. Thus, for designing the optimum array, the shape of the element should also be taken into account.

Using this module, the user can choose suitable shapes of individual transducers.

For the selection of the shapes of the transducers, three alternatives are provided. A menu is displayed, listing the various alternatives and prompting the user for the choice. The element shapes available in this package are:

1) rectangular disc
2) square disc
3) circular disc
5.2.3 Module III: Reading in and Modification of Input Parameters

Once the shape of the array and shape of the element have been finalised, the user has to feed in other relevant array parameters. The program prompts the user for each parameter.

The initial reading is done in two screens. In the first screen the program asks for the dimensions of the elements, depending on the shape of the element already chosen. For example, if the element shape chosen is rectangular disc, the program prompts the user for length, breadth and thickness of the element. In the same screen, the number of elements to be used in the array is also required to be read into the system.

In the second screen, the dimension of the array has to be specified. For example, if the shape of the array chosen is rectangular, the number of elements in the X-direction and the number of elements in the Y-direction are required for the program. If it is a circular array, the number of circles and elements in each circle are required.
Once a set of parameters has been entered and a result obtained, the user can vary any one of the input and re-execute the program to see the effect of that change. For facilitating this change of variables, the program prompts the user by displaying the dimension to be changed along with the current value in brackets.

5.2.4 Module IV: Design Calculations

This module has absolutely no interaction with the user. Once all the choices have been made and the parameters loaded, this module is invoked by the program. This module carries out all the necessary mathematical computations required to predict the optimum element configuration, satisfying the requirements of the user.

5.2.5 Module V: Display of Results

This module displays the result, once the design calculations are over. It also displays the options made by the user as well as the parameters entered along with the percentage reduction in interaction force.
The results are displayed in four screens. In the first screen, array details are displayed. This includes the number of elements, shape of the array, shape of the elements etc.

The second screen provides the optimum element configuration of the array. This gives the spacing between each and every element. This also provides an option for displaying the pictorial representation of the distribution of elements for very small arrays.

The third screen displays the beam patterns of both conventional $\lambda/2$ spaced array and optimally formulated array. This enables the designer to make a comparative study of the sidelobe levels and beamwidths of both arrays.

The fourth screen provides a comparative study of the array performances in both transmitting and receiving applications. Here, the percentage
reduction in interaction force, the array gain, beamwidth and most intense sidelobe levels of both conventional \( \lambda/2 \) spaced array and optimally formulated array are tabulated.

5.3 CONCLUSIONS

A computer simulation package has been developed for predicting the optimum array as per the user's requirements. This package contains only limited menu for selecting the parameters. The capability of this package can be enhanced by incorporating additional facility for selecting the other factors such as material specifications, other array shapes like curved apertures, cylindrical arrays etc.