THE UNIVERSITY OF MICHIGAN

COLLEGE OF ENGINEERING

DEPARTMENT OF ELECTRICAL ENGINEERING

Radiation Laboratory

THEORETICAL AND EXPERIMENTAL TOPICS FOR ANTENNA RESEARCH

FINAL REPORT

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Our effort on this project was directed toward the selection and examination of challenging antenna problems, the solutions of which were urgently needed in current military or civilian applications. The project was a joint effort of nine members of the Radiation Laboratory, but most of the study was performed by Dr. Dipak L. Sengupta. Our objective was to produce a complete and well organized proposal by which we could interest a potential sponsor in providing multi-year support for a comprehensive research effort on a few key antenna problems. The result was a 48-page proposal completed in May, 1970. A copy of the introduction and summary of the proposal is attached (a copy of the complete proposal will be provided upon request). In June copies of the proposal were sent to the following; they were sent as informal, unsolicited proposals without ORA numbers. No budget was provided but we suggested $150,000.00 per year for 2 or 3 years.

(1) Office of Naval Research
(2) Advanced Research Project Agency
(3) U.S. Navy Electronics Laboratory Center
(4) Air Force Cambridge Research Laboratory
(5) Lincoln Laboratory

As of this date, there has been no reaction from any of these potential sponsors.

The results of the study was organized so as to provide material for proposals on some of the individual projects described in the proposal. Some of the material was used in proposal ORA-70-570-KB1, to develop an antenna array for operating on a non-planar surface, e.g. aircraft fuselage. We were an unsuccessful bidder on that problem. An informal version of a proposal on the transient antenna problem was sent to Kirtland Air Force Base. We are optimistic about the chances of obtaining a contract from them on this and related work.

This study has been quite worthwhile in that it has given us an opportunity to look at the more significant antenna problems likely to be encountered in future military and civilian radar, communication and sensing programs. We have been able to submit a good proposal for a long term research effort to several possible sponsors. Despite these difficult times we have hope that an important part of our proposed work will be funded either as a result of the above proposals or as a result of re-written proposals for one or two of the key problems.

I

GENERAL INTRODUCTION

The purpose of the present proposal is to generate a well-coordinated broad-based research program in the general field of antennas at The University of Michigan Radiation Laboratory. The research envisioned here is fundamental enough to be intellectually rewarding and at the same time it would provide challenging topics of proper academic depth for Doctoral Theses within the Department of Electrical Engineering at The University of Michigan. The investigation of the problems discussed herein would not only extend the frontiers of the field of antennas, but also be of considerable practical value.

In writing this proposal the experience and interests of the research personnel of the Radiation Laboratory have been kept in mind. Consequently a few problems of general interest have been left out. The areas of research discussed in the proposal are broadly classified into four different categories. A brief discussion of these four areas is given below.

1.1 Summary

The first area of research considered is entitled "Transient Phenomena in Antennas". This is an important area of antenna research where surprisingly little basic information is presently available. The reason for this may be that until now there was no practical interest in such problems due to the lack of availability of transient signals of extremely short duration. However, during the past few years, with the modern development of extremely short pulse generation techniques, it has become important that the performance of antennas for such signals be known better. It appears that under such signal conditions a few of the basic antenna concepts such as directivity, radiation pattern, etc, be either redefined or modified.

The second area of research is entitled "Investigation of Non-Planar Antenna Arrays". This is an important area of research where much more fundamental work is needed. Here we emphasize the analysis of the radiation properties and the effects of mutual coupling between elements in such arrays. It is believed that the results of such investigation would provide the proper background for the practical implementation of non-planar antenna arrays.

The third area of research entitled "General Studies of Diffraction Type Antennas", considers the application of geometrical theory of diffraction for the development of theories for some new and useful antenna configurations and also for theoretical clarification of some hitherto unexplained phenomena encountered in a few conventional antennas. Although only a few specific types of antennas are mentioned, during the course of the investigation many other problems of basic importance may appear in this category.

The fourth and final area of research considered is entitled "Computer Solution of Boundary Value Problems". There exists many antenna configurations where analytical solutions of practical value are non-existent because of the complex nature of the geometry involved. In such cases numerical solutions may be obtained with the help of modern high speed computers. A few specific cases are discussed where the computer can provide meaningful solutions.

Although only the theoretical aspects of the problems are discussed in detail, in many cases meaningful experimental investigations must be carried out to obtain dependable results. We mention such experimental procedures at appropriate places.

1.2 Possible Applications

In this section we give a short discussion on the possible practical applications of the results obtained from the investigation of the above topics.

Wide-band radars use extremely short pulses. The antenna used is one of the critical factors that determine the minimum length of the pulse that can be used in a practical system. It is imperative therefore to know the antenna and/or antenna array

properties for such signals. The results of the research envisioned would clarify the limitations imposed by antennas on the transmission and reception of extremely short pulse signals.

In planar phased arrays there exists a fundamental limitation with regard to the steering of the beam over a large (hemispherical or spherical) region of space and over a wide band of frequencies. The physical symmetry of some non-planar surfaces may be conveniently utilized to avoid such difficulties in the case of non-planar phased arrays. It is believed that the study proposed here would bring out enough information so that such arrays may be brought into practical use.

The study of diffraction type antennas discussed above would have many practical applications depending on the particular systems where they are used. The parasitic loop counterpoise antenna, when developed, would have direct application in air traffic control systems. Due to its special radiation pattern characteristics this antenna appears to be capable of bringing out superior performance from the existing VOR (VHF OmniRange) systems. The back-fire antenna would find application either singly or in the form of an array to provide high gain performance in the VHF and UHF region. Accurate knowledge of the radiation properties in the backward region of parabolic dish antennas is important when such antennas are used in low noise receivers, e.g. radio-telescopes. The study of parabolic dish antennas proposed here would not only provide such knowledge it may also enable the designer to control the amount of such radiation if necessary.

The rudimentary horn is an extremely broadband linearly polarized antenna. It may have various applications in the frequency range from HF to microwave regions. In HF communications it could be used in conjunction with rhombic antennas for polarization diversity type of reception. When properly designed the antenna may find application as a broadband feed for parabolic dish antennas.