

# preface

A nine-month sequence in antenna theory and design is offered on a yearly basis at the author's institution. The first and second quarters are open to seniors and first-year graduate students; the third quarter is at the graduate level. The sequence presupposes a background at the intermediate level in electromagnetic theory and a knowledge of introductory transmission line theory, including Smith charts and waveguide modal analysis. The present book has evolved from the lecture notes for the antenna sequence.

It has been the author's experience, in teaching this sequence for the past five years, that the various topics which seemed to provide a balanced treatment were not to be found at an introductory level in a single textbook currently available. Further, some recent developments, the importance of which is widely recognized, were only available in the research literature. Student frustration over nonuniformity of notation from article to article and over the economic hardship associated with buying a multiplicity of texts that would only be partially used, provided the original motivation for the lecture notes. The editing of these notes by successive groups of students is appreciated, and it is hoped that their criticisms have benefited the final product.

The topic coverage has been influenced by the author's experience and by the needs of local industry in the Los Angeles area. The reader will find emphasis on microwave antennas, particularly on arrays for use in radar and communication systems. The practical applications of such antennas have grown to occupy a major portion of the field, so it is hoped this emphasis will find wide appeal. However, other topics have not been neglected, as can be observed from the Table of Contents.

The text is divided into four parts. Part I commences with a review of electromagnetic theory and then proceeds to the establishment of integral relations between a collection of sources (the antenna) and the radiated field caused by these sources. A convenient division of antennas into two types emerges from this development. The first type, for which the actual sources are known quite well, includes dipoles, loops, and helices, and their pattern characteristics are studied in turn. The second type, for

which the close-in fields are known with reasonable accuracy, can be analyzed in terms of equivalent sources. This category includes horns, slots, and patches, all of which are considered in some detail.

Part II is concerned with the analysis and synthesis of one- and two-dimensional arrays. The antenna elements studied in Part I form the constituent parts of these arrays, and focus is on the pattern characteristics. The synthesis procedures of Dolph and Taylor are introduced and extended to pattern requirements involving arbitrary side lobe topography.

In Part III the emphasis is shifted to the impedance properties of antenna elements, used either singly or in arrays. Hallén's integral equation formulation of the self-impedance of a cylindrical dipole is developed and extended to strip dipoles. Several types of solution are studied, including those obtained by the method of moments and by functional expansion. Babinet's principle is used to extend these results to slots. Mutual impedance, so important in the design of arrays, is formulated with the aid of the reciprocity theorem and then calculated for the most commonly used antenna elements. All of this information of self-impedance and mutual impedance is then employed in the design of feeding structures for single elements and for linear and planar arrays, including those which scan.

Part IV is devoted to antennas with continuous (or quasi-continuous) apertures. Long wire antennas such as the rhombic and  $V$  are studied and the properties of many surface wave structures are analyzed. These include slow wave types such as dielectric-clad and corrugated ground planes and fast wave types, notably leaky waveguides. The book concludes with an introductory treatment of reflectors and lenses, antenna types to which many of the principles of optics can be applied.

The three courses that form the antenna sequence at the author's institution span three months each, with four hours of lecture offered per week. The first course covers Chapters 1, 2, and 4 plus the first six sections of Chapter 5, the first fifteen sections of Chapter 7, the first twelve sections of Chapter 8, and the first three sections of Chapter 9. It thus concentrates on wire antennas (dipoles, monopoles, loops, and helices) after introduction of the fundamentals. The second course covers Chapter 3, the remainder of Chapters 7, 8, and 9, and all of Chapter 10. It emphasizes aperture antennas (slots, patches, reflectors, and lenses). The third course is devoted to pattern synthesis and relies on the last half of Chapter 5 and all of Chapter 6, plus some of the current literature.

For someone wishing to give a balanced offering of antenna topics in a one semester course, a combination which should prove satisfactory would contain Sections 1.1 through 1.6, Sections 1.10 through 1.18, Sections 2.1 through 2.6, Sections 3.1 through 3.6, Sections 4.1 through 4.4, Sections 5.1 through 5.3, Section 7.8, Sections 7.13 through 7.15, Sections 8.1 through 8.6, Sections 10.1 through 10.5, and Sections 10.10 through 10.11. This would provide exposure to the fundamentals, to wire antennas, to aperture antennas, to the elements of array theory, to the problem of feeding arrays in the presence of mutual coupling, and to the application of geometric optics to the design of reflector and lens antennas.

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