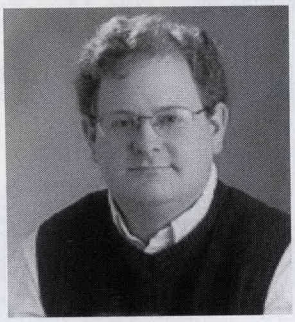

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Conformal Array Antenna Theory and Design, by Lars Josefsson and Patrik Persson, IEEE Press Series on Electromagnetic Theory, IEEE Press/John Wiley, 2006, xiv + 472 pages. $105.00, ISBN 978-0-471-46584-3

The authors begin with a definition from the IEEE Standard 145-1993:

> An antenna [an array] that conforms to a surface whose shape is determined by conditions other than electromagnetics, for example aerodynamic or hydrodynamic.

This definition includes self-standing circular or other shaped structures, but it more often refers to antennas on or in a material surface such as a metal or a dielectric.

This book is the most complete text in the area of conformal arrays. The authors have undertaken to present as much of the theory and as many technological applications as possible in order to help engineers advance the technology. The book presents numerous references and photographs of actual systems and experimental models. This book has the potential of being a classic text in the area. It presents significant detail in areas where other texts offer brief and non-rigorous treatments, and should be a necessary component of a complete library on antenna technology. Part of the problem that engineers face in getting into this area of conformal antennas and arrays is that there is no complete mathematics to count on; instead, there is a variety of techniques that work in some situations and not in others. Clearly, this situation is not solved by this or any other book, but the authors have presented their insights, gained from years of experience, and they guide the reader through this collection of methods to solve what can be solved and to reliably point out what cannot. They make clear where the research areas exist and mention possible avenues of approach.

There have been other books and book chapters dealing with conformal antennas and arrays. Texts by Wait [1] and later Tai [2] dealt with elementary sources and arrays on or apertures in canonical surfaces such as flat sheets, circular and elliptical cylinders, spheres, and cones. Most of these were perfectly conducting, although Wait did treat the case of a slot in a dielectric-coated cylinder. The specific subject of conformal arrays was also addressed in an earlier report edited by R. C. Hansen [3].

The theoretical analysis of general conformal arrays is a very difficult topic, with exact models only for arrays on regular shapes such as cylinders and spheres, and then only with metallic surfaces. Theoretical formulations for general shaped dielectric surfaces or dielectric over metal ground surfaces do not exist in any closed form, but antennas on these structures can be analyzed by computational methods if the surfaces or arrays are not too large.

High-frequency methods, based on Geometrical Optics and later on the Geometric Theory of Diffraction and the Uniform Theory of Diffraction, have had success dealing with antennas on large metallic structures. They have been successfully used in hybrid forms with the Method of Moments and other numerical techniques. The authors make it clear that much remains to be done before the analysis of conformal arrays becomes routine.

Chapter 1 is quite short, but it presents good historical and introductory material. It is accompanied by a comprehensive set of references, and a number of photos of old and new conformal structures.

Chapter 2 discusses the theory of circular arrays and phase-mode theory. This is a good introductory chapter in that it introduces concepts that are useful to the discussions of the more-general conformal structures treated in remaining chapters. While much of the material is new, the chapter also summarizes the well-known phase-mode analysis in a compact and clear presentation. The principal reference to this material is the chapter by Davies in the *Handbook of Antenna Design* [4], but this chapter summarizes the available literature, and presents a cohesive discussion.

Chapter 3 discusses the purely geometrical characteristics of conformal arrays in the context of looking at projected apertures of various curved conformal shapes, flat multi-face arrays, and even multi-faceted surface arrays. The chapter includes some useful comparisons of effective area for arrays as they are scanned from zenith to horizon.

Chapter 4 is an excellent chapter for those looking to be updated regarding theoretical considerations. It begins with a very broad-brush treatment of the various methods of numerical analysis applicable to certain conformal structures. These are short but well-written sections that explain and then compare the basics of the variety of approaches. These sections include little mathematical detail, leaving that to the copious references, but they clearly explain the reasons for using each approach.

The chapter also discusses several asymptotic methods for treating large conformal structures. However, here the book focuses on the extensions of the Uniform Theory of Diffraction for perfectly conducting surfaces and some relatively thin dielectric-

coated surfaces. It concludes with a more-detailed treatment of two examples, a waveguide array over a perfectly conducting surface, and a microstrip array over a coated multilayer dielectric substrate on a perfectly conducting surface.

This chapter also has a very useful appendix on ray theory, discussing the Watson transformation, the Fock substitution, steepest-descent integration, surface waves, and some useful commentary.

In Chapter 5, the authors begin to discuss geodesics, the ray path along the conformal surface. Geodesics are the essential ingredient of ray theory. They are relatively easy to evaluate for singly curved surfaces, but extremely complicated for doubly curved surfaces. Josefsson and Persson devote Chapter 5 to this topic, giving solutions for those cases of singly curved and some rotationally symmetric doubly curved surfaces. They describe the details of the numerical solution for those surfaces for which there is no closed-form solution.

Chapter 6 deals with antennas and arrays on singly curved surfaces. Most of these are conducting cylinders, but also other convex singly curved surfaces are treated. They treat the mutual coupling between individual elements first. They then discuss arrays using UTD and the Method of Moments to obtain embedded array-element patterns for waveguide, and then microstrip patch elements, on coated circular cylinders. At the end of the chapter, the presentation includes a discussion of published results for aperture and microstrip antennas, and arrays on conical surfaces with metal or metal with thin dielectric coatings.

Chapter 7 discusses doubly curved surfaces. It includes theoretical and measured results from Dr. Persson's thesis that describe waveguide aperture radiation and coupling. Some microstrip-patch antenna radiation data is included, referencing various works of Sipus and Barum and other colleagues (see, for example, [5]).

Chapters 8 through 10 deal with the practical aspects of conformal arrays. Chapter 8 references nearly all the existing conformal arrays in print, and gives pattern and polarization details for several of these. Discussions include multi-faceted surfaces, and singly and doubly curved metallic surfaces. This chapter provides an up-to-date catalog of the state of the art in conformal arrays, and Chapter 9 does the same thing for beamforming systems. The chapter begins with a discussion of the many analog scanning systems for conformal (primarily circular) arrays that were based either on switch matrices, Butler matrix feed systems, or switched or mechanically commutated lens systems. Digital beamforming and adaptive control are addressed briefly at the end of the chapter.

Chapter 10 deals with antenna-pattern synthesis, and emphasizes the peculiarities of using phase modes for synthesis of circular-array patterns. The chapter discusses many of the conventional methods usually applied to linear arrays, and presents interesting comparisons of the two situations. Most of these results are new and not available elsewhere.

Chapter 11, the last in the book, discusses scattering from conformal arrays, including some cylindrical arrays with dielectric coating. Once again, the presentation is insightful and well studied.

In conclusion, this is clearly the most comprehensive treatment of conformal arrays available. The authors discuss other methods, but emphasize the Uniform Theory of Diffraction in their presentation. When used in hybrid combination with numerical methods, this procedure gives useful results for structures too large for all-numerical solutions, but it isn't appropriate for other than conducting bodies or bodies covered with thin dielectric layers. This is a major remaining problem for conformal-array research, and it remains a big step.

The essential feature of the text is that it is comprehensive, and includes discussions of nearly all of the published work on conformal arrays. The tone of the book is that it is scholarly, thorough, and readable. It should be a useful reference for anyone working in the practical application of array antennas, and for anyone seeking to define research topics in the area of conformal arrays.

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3. R. C. Hansen (ed.), *Conformal Array Design Handbook*, Dept. of the Navy, Air Systems Command, September 1981, AD A110091.

4. D. E. N. Davies, "Circular Arrays," in A. W. Rudge et al. (eds.), *Handbook of Antenna Design, Volume 2*, London, Peter Perigrinus, 1983, Chapter 12.

5. Z. Sipus, N. Barum, and J. Bartolic, "Analysis of Rectangular Microstrip Patch Antennas on Spherical Structures," *Microwave and Optical Technology Letters*, **36**, February 2002, pp. 276-280.

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Recent Books

The following is a list of recently published books that have been received by the Associate Editor since the last issue of the *Magazine* was published. Reviewers are sought for these books, so readers are encouraged to let the Associate Editor know if they are interested in reviewing a particular book.

The Paraboloidal Reflector Antenna in Radio Astronomy and Communication: Theory and Practice, Jacob W. M. Baars, (Springer, 2007)

Smart Antennas for Wireless Communications with Matlab, Frank Gross (McGraw Hill, 2007)

Bayesian Bounds for Parameter Estimation and Nonlinear Filtering/Tracking, edited by Harry L. van Trees and Kristine L. Bell (Wiley, 2007)