Some results are shown in Figs. 1 and 2 for $k = 2$ (see Table 1) and $\alpha = 2$, $\gamma = 6$ (see Table 2) where all the adaptive sampling laws have the same number of samples as in the periodic case.[1] Efficiencies of the various adaptive sampling laws and error models are shown in Table 3 and compared to the case of constant sampling. The resulting sampling periods are shown in Table 4.

The results obtained show that for adaptive sampling, the error converges better to the equilibrium than for a constant sampling period involving at most an equal number of samples for the chosen k constant. This may be interpreted immediately from the fact that adaptive sampling schemes present a closer behavior to the equivalent continuous system (i.e., that constituted by the same plant but without involving the use of a zero-order hold). Thus we conclude that although a rigorous treatment is difficult (even for classical control problems [4], [5]), due to the complex nonlinear nature of the problem, this experimental work together with the previous knowledge about adaptive sampling techniques seems to indicate that their applications to these hybrid error schemes may be helpful in improving the error convergence to zero. Stability is preserved under the same conditions as in [6]–[8].

[1]If, as usual, we do not have *a priori* knowledge for a convenient choice of k, a "good strategy" is to choose it arbitrarily, which probably will lead to a sequence of sampling periods belonging to the boundary of $[T_{min}, T_{max}]$ and therefore to a "bang-bang" sampling design.

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Book Reviews

The following reviews were selected from those recently published in various IEEE TRANSACTIONS *and Group/Society Magazines and Newsletters. They are reprinted here to make them conveniently available to the many readers who otherwise might not have ready access to them. Each review is followed by an identification of its original source.*

Antenna Theory; Analysis and Design—C. A. Balanis. (New York: Harper and Row, 1982, 790 pp., $39.50.) *Reviewed by Rajeev Bansal, Elec. Eng. and Comput. Sci., Univ. of Connecticut, Storrs, CT 06268.*

Since last year three new books have become available to educators searching for an up-to-date text on antennas for senior and graduate students of electrical engineering. My remarks here are confined to Prof. Balanis' entry in this field. (The interested reader is referred to the October 1981 and the February 1982 issues of the Newsletter for reviews of the other two textbooks.) This review stems from my recent experience with *Antenna Theory* as the primary textbook in a graduate course that I taught at the University of Connecticut. Before a chapter-by-chapter analysis is undertaken, a few preliminary remarks seem to be in order. As Prof. Balanis states in his preface, the text is intended primarily for a two-semester sequence in antenna theory. Fortunately, however, the material in each chapter has been neatly organized into sections and subsections so that, by omitting the most difficult sections, the teacher can provide sufficient breadth of topics even in a one-semester course without loss of continuity. Making the reasonable assumption that the intended audience would possess the necessary background in basic electromagnetic theory and vector calculus, Prof. Balanis has devoted his book solely to a treatment of antennas right from page 1.

Having succinctly introduced the subject matter in Chapter 1, the author proceeds to define in Chapter 2 the various terms used by antenna engineers. IEEE standard definitions have been quoted throughout. The chapter concludes with interpretations of Friis transmission equation, the radar range equation, and antenna temperature. The derivation of the effective antenna temperature is a little too short for beginners to follow. Also, since even the Hertzian dipole is not formally introduced till Chapter 4, students may have some difficulty in immediately relating the various definitions to the parameters of an actual antenna.

Chapter 3 presents the basic mathematical development leading to general expressions for the electromagnetic field of known current distributions. The reciprocity theorem is derived and its implications for the pattern of a receiving antenna are discussed.

Chapters 4 and 5 are devoted, respectively, to a treatment of linear wire antennas and loops. For the advanced student (or practicing engineer), both chapters include considerable material on ground effects.

Chapter 6 is a more or less standard development of array theory. A distinguishing feature is the inclusion of a concise section on superdirectivity.

Chapter 7 derives self- and mutual-impedances of dipoles based on the somewhat dated induced emf method. The chapter concludes with a short introduction to the moment method.

Chapters 8 through 10 introduce the student to a variety of antenna configurations suited for broad-band applications. Step-by-step design procedures are given for Yagi–Uda arrays and log-periodic dipole arrays which should prove very useful to the practicing engineer as well. In addition, Chapter 8 incorporates much valuable information on practical matching techniques such as baluns and transformers, and T- , gamma, and omega matches. It is extremely difficult, if not impossible, to keep a book of such scope free from occasional errors. In Chapter 9, when describing the operation of a helical antenna in axial mode, the author gives the correct expression for the far field but incorrectly attributes the $\cos\theta$ dependence of the field to a "uniform current" in each turn. Another regrettable lapse occurs in Chapter 10 in specifying the geometry of an LPDA. The definitions of the usual parameters σ and α (Eqns. 10-26a and 10-28) are clearly incompatible.

Chapters 11 through 13 deal with aperture antennas. After illustrating the usefulness of the field equivalence principle through simple examples, the author discusses various horns, reflectors, and lens antennas. An elementary introduction to microstrip antennas is included as is a brief treatment of the geometric theory of diffraction.

Antenna pattern synthesis is the topic of Chapter 14. The classical synthesis techniques such as Schelkunoff polynomial method, Fourier transform method, Woodward method, etc., are illustrated with suitable examples.

The final chapter of the book is a helpful introduction to the methods used in basic antenna measurements. Antenna ranges and the associated instrumentation are described and the fundamentals of scale model measurements are presented. The descriptions of current and impedance measurements are rather superficial but considering that most other antenna texts omit the subject of measurements altogether, the brevity of the treatment is understandable.

The inclusion of extensive tables, curves, and eight useful appendices enhances the value of the text as a handy reference book. Computer programs are included at the end of many of the chapters, and both analytical and design problems are incorporated throughout the book. Another valuable aid to the student is the three-dimensional graphical illustrations for displaying radiation patterns. All things considered, the book should be a strong contender as a senior or graduate text on antennas.

Reprinted from *IEEE Antennas and Propagation Society Newsletter*, vol. 25, no. 2, pp. 21–22, April 1983.

Theoretical Foundations of Programming Methodology—Manfred Broy and Gunther Schmidt, Eds. (Amsterdam, The Netherlands: D. Reidel, 1982, 652 pp., $39.50.) *Reviewed by Cliff B. Jones, University of Manchester, Manchester, England.*

This book is for computer scientists who acknowledge the importance of theory. It contains an excellent collection of 18 papers based for the most part on the NATO summer school lectures at Marktoberdorf in 1981. Since the book is part of the NATO Advanced Study Institute Series, one might have expected a lower price so that the ideas could be widely disseminated. However, the quality of much of the material makes the book well worth buying even at the price.

All the contributions were stimulating; however, because of space limitations, I am confining my review to a number of particularly interesting papers.

The paper by Burstall and Goguen, "Algebras, Theories and Freeness: An Introduction for Computer Scientists," should be required reading for anyone interested in abstract data types. It is an admirably readable and authorative guide to the terminology used in algebraic presentations of data types. The companion paper by Wirsing and Broy also aims to review approaches (e.g., initial versus terminal), but is somewhat harder to read. Denotational semantics is covered by papers from Scott (who was unable to attend the school) and Stoy. Scott's paper describes a new, neighborhood, approach to the foundations of recursive and self-referential functions. The 148 pages, while not easy to read, present the topic in a teachable way. Pending the promised textbook, this material is the most useful course information since Stoy's book. Stoy's paper gives a carefully motivated review of some of the techniques of language definition, such as continuations.

Much of the work on reasoning about parallelism is now attempting to use some form of modal logic. The paper by Manna, "Verification of Sequential Programs: Temporal Axiomatization," provides an invaluable reference to the forms of reasoning that can be used. The results are not, I believe, entirely convincing, but until simpler methods are found, a logic that copes with time by operators is worth reviewing. Seven other papers on program development and verification cover both axioms themselves and the use of formal methods in the development of interesting programs.

The papers in the parts of the book on infinite structures and concurrent programs appear to be of more use to the specialist than to a general reader. Their titles include "Fundamental Properties of Infinite Trees," by B. Courcelle; "Behaviors of Processes and Synchronized Systems of Processes," by M. Nivat; "A Tutorial on the Split Binary Semaphore," by E. W. Dijkstra; and "Discrete Event Simulation Based on Communicating Sequential Processes," by W. H. Kaubish and C. A. R. Hoare.

As an incidental feature, the book contains sheet music that is intended to characterize the authors, and I recommend that those who do not read music have someone play it for them.

Reprinted from *IEEE Computer Magazine*, vol. 16, no. 6, p. 125, June 1983.

Dosimetry of X-Ray and Gamma-Ray Beams for Radiation Therapy in the Energy Range 10 keV to 50 MeV—National Council on Radiation Protection and Measurement Report No. 69. (Washington, DC: NCRP Publications, 1981, ISBN: 0-913392-55-3, 110 pp., $12.) *Reviewed by S. Julian Gibbs, Radiology and Radiological Sciences, Vanderbilt University Medical Cen., Nashville, TN.*

Perhaps the best way to begin a review of NCRP 69 is a brief discussion of what it is not. It is not a textbook. It presupposes in its readership an in-depth knowledge of the field. Its coverage is not exhaustive, but rather selects from current problems in its subject matter. It is not a "cookbook" laboratory manual. Instead, it is a very useful handbook for the physicist or engineer who is involved in the performance of dosimetry of high-energy X-ray and γ-ray beams for therapeutic radiology. In a well-organized way, it points out the pitfalls that can trap even an experienced individual. Its stated purpose in Chapter 1 is "to describe the systems and methods by which the absorbed dose to a homogeneous phantom simulating a patient undergoing radiation therapy may be determined and related to national radiation standards." Thus, it should be extremely useful to the establishment of a new therapeutic radiology facility or a new quality assurance program in an existing facility, and to the design and development of dosimetric apparatus.

After a brief introduction and overview, the book is divided into four sections. The first (Chapter 2) discusses the fundamental physics of photon dosimetry in the covered energy range. That is followed by a discussion of dosimetry equipment (Chapters 3, 4, and 5), both standard and field. Chapter 6 deals with routine testing of radiation therapy equipment, including commissioning, calibration, and other measurements. The final chapter discusses errors and uncertainties in dose, its measurement, and its delivery to patients.

The text was written by a committee, like all NCRP reports. However, it is well done and well edited—again like all NCRP reports—making it quite readable. Only a few typographical errors were noticed in the text. Most are inconsequential. Although it does not bear the full weight of law, the text is authoritative in intent. It establishes minimum standards of dosimetry that should be observed by all therapeutic radiology operations. All are reasonable and represent the current state of the art. Thus it should be prescribed reading for all who are involved in dosimetry for radiotherapy, as well as all who are involved in the design or manufacture of radiotherapeutic or dosimetric equipment.

Reprinted from *Engineering in Medicine and Biology Magazine*, vol. 2, no. 2, p. 46, June 1983.

Introduction to the Theory of Error-Correcting Codes—Vera Pless. (New York: Wiley-Interscience, 1982, xi + 169 pp.) *Reviewed by Ian F. Blake, Dep. Elec. Eng., Univ. of Waterloo, Waterloo, Ont., Canada.*

Contents; 1) Introductory Concepts, 2) Useful Background, 3) A Double-Error-Correcting BCH code and a Finite Field of 16 Elements, 4) Finite Fields, 5) Cyclic Codes, 6) The Group of a Code and Quadratic Residue (QR) Codes, 7) Bose–Chaudhuri–Hocquenghem (BCH) Codes, 8) Weight Distributions, 9) Designs, 10) Some Codes Are Unique.

The subject of error-correcting codes is finding increasing popularity in undergraduate and graduate mathematics courses as an