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BOOK REVIEW

BALANIS' ADVANCED ENGINEERING ELECTROMAGNETICS, 3RD EDITION [BOOK REVIEW]

Fatih ERDEN

National Defence University, Department of Electronics Engineering, Istanbul, Turkey, ferden@dho.edu.tr

ABSTRACT

The third edition of "Balanis' Advanced Engineering Electromagnetics" marks a significant advancement in the field of electromagnetics education and research. This edition not only retains the foundational theories of its predecessors but also introduces cutting-edge topics like artificial impedance surfaces, offering a comprehensive overview of contemporary electromagnetic technologies. With its detailed coverage of advanced topics such as metasurfaces, radar cross-section reduction, and optimization of antenna parameters, the book stands as an indispensable resource for students and professionals in electrical engineering. It bridges theoretical concepts with practical applications, making it an essential tool for both teaching and research.

Keywords: *Electromagnetics, artificial impedance surfaces, metasurfaces, antenna optimization, radar cross-section reduction.*

BALANIS'İN İLERİ MÜHENDİSLİK ELEKTROMANYETİĞİ, 3. BASKI [KİTAP İNCELEMESİ]

ÖZ

"Advanced Engineering Electromagnetics" adlı kitabın üçüncü baskısı, elektromanyetik eğitim ve araştırma alanında önemli ilerlemeleri sergilemektedir. Bu baskı, seleflerinin temel taslaklarını ve teorik içeriklerini korumanın yanı sıra yapay empedans yüzeyleri gibi en modern konuları tanıtarak, en yeni elektromanyetik teknolojileri kapsamlı bir şekilde sunmaktadır. Teorik kavramları pratik uygulamalarla birleştiren bu kitap, metayüzeyler, radar kesit alanı azaltma ve anten parametrelerinin optimizasyonu gibi ileri düzey konuların ayrıntılı bir şekilde ele alınmasıyla, elektrik ve elektronik mühendisliği öğrencileri ve araştırmacıları için vazgeçilmez bir kaynak olmaya devam edecektir.

Anahtar Kelimeler: *Elektromanyetik, yapay empedans yüzeyleri, metayüzeyler, anten optimizasyonu, radar kesit alanı azaltma.*

1. INTRODUCTION

"*Advanced Engineering Electromagnetics*" by Constantine A. Balanis has been a cornerstone in the field of electromagnetics since its first edition in 1989. The book has significantly contributed to electromagnetics education from undergraduate to graduate levels and in various research activities across a wide spectrum of the field. Its evolution reflects the dynamic changes and advancements in the world of electromagnetics.

The third edition of "*Balanis' Advanced Engineering Electromagnetics*," (Balanis, 2024), set for release in electronic and hard copy formats in January or February 2024, has completed its design and production stages and is currently in the final phase of collective printing. This edition, which I had the privilege of reviewing thanks to the materials provided by Professor Balanis and my involvement in the translation of the second edition to Turkish (Balanis, 2021a), upholds the foundational strengths of the previous editions and incorporates substantial advancements. Among these is a new chapter on artificial impedance surfaces (AIS), highlighting current and advanced electromagnetic technologies, including metasurfaces. This book review aims to explore the technical enhancements and educational significance of the third edition, underlining its importance in both naval and civilian electrical engineering education.

Electromagnetic theory, central to electrical engineering and physics, plays a crucial role in the understanding and designing of systems involving antennas, microwave circuits, radio frequency and optical communications, wireless technologies, etc. This review evaluates the third edition's expanded scope and modernized approach, emphasizing its significance in electromagnetic research and education.

2. EVOLUTION AND CONTENT OF EDITIONS

2.1. First Edition (1989)

The first edition was a welcome addition to graduate electromagnetic theory courses, suitable for a two-semester course. It included fundamental theory which can be found in many classic texts, along with canonical examples like modes in waveguides and scattering from circular cylinders. The book was praised for its readability, coherence,

and the inclusion of contemporary material (Glisson, 1989). Chapters 8-11 provided a balance of classical examples and contemporary applications, relevant to integrated and fiber optics. Modern numerical and asymptotic techniques were introduced in Chapters 12 and 13, marking significant differences from older electromagnetic texts.

2.2. Second Edition (2012)

The second edition marked a significant enhancement of the book's content, introducing innovative elements and the developments in the field (Orlandi, 2015). A key addition was a new chapter on diffraction by a wedge with impedance surfaces, providing an in-depth exploration of this complex topic. The edition also introduced an insightful section on double negative (DNG) metamaterials, exploring the unique properties and applications of these materials with negative refractive indices. Further enriching the book was the inclusion of a section on artificial impedance surfaces, including artificial magnetic conductors (AMC), electromagnetic band gap (EBG), and photonic band gap (PBG) structures. This section, outlined in Section 8.8 of the Second Edition, delved into various applications and the evolving role of these surfaces, a topic not covered in the first edition. Additionally, the second edition was updated with numerous new figures, photos, tables, and end-of-chapter problems, enhancing the reader's learning experience.

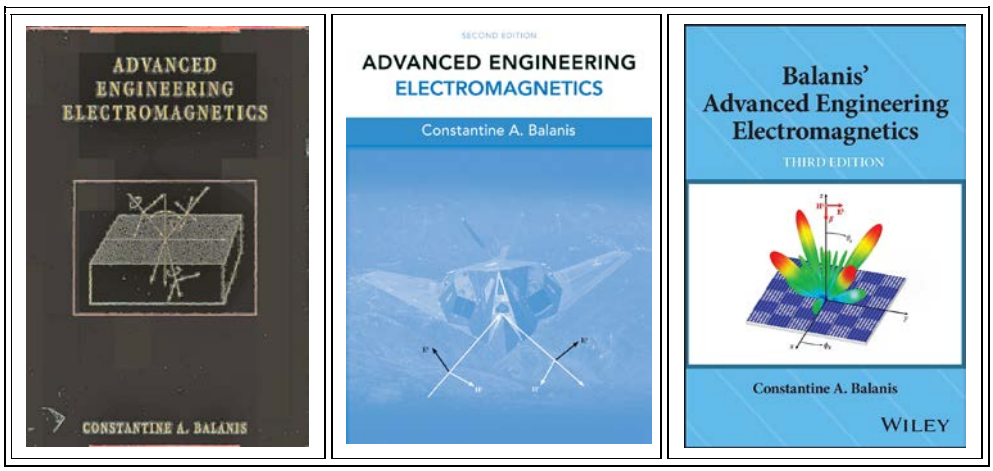

Figure 1. *The Evolution of Advanced Engineering Electromagnetics: 1st Edition, 2nd Edition, 3rd Edition.*

2.3. Third Edition (Early 2024)

The third edition (Balanis, 2024), represents a significant step forward in the evolution of the text. This edition not only preserves the comprehensive approach of its predecessors but also integrates cutting-edge advancements in electromagnetic technologies. A noteworthy highlight is the inclusion of a new chapter, Chapter 16, dedicated to artificial impedance surfaces (AIS). This chapter provides a deep dive into metasurfaces, focusing on their application in controlling radar cross-section and optimizing antenna parameters.

Contents of the 3rd Edition:

1. Time-Varying and Time-Harmonic Electromagnetic Fields
2. Electrical Properties of Matter
3. Wave Equation and Its Solutions
4. Wave Propagation and Polarization
5. Reflection and Transmission
6. Auxiliary Vector Potentials, Construction of Solutions, and Radiation and Scattering Equations
7. Electromagnetic Theorems and Principles
8. Rectangular Cross-Section Waveguides and Cavities
9. Circular Cross-Section Waveguides and Cavities
10. Spherical Transmission Lines and Cavities
11. Scattering
12. Integral Equations and the Moment Method
13. Geometrical Theory of Diffraction
14. Diffraction by a Wedge with Impedance Surfaces
15. Green’s Functions
16. Artificial Impedance Surfaces

The third edition enhances the reader's learning experience by including over 4,500 PowerPoint slides and 53 MATLAB programs, which cover computations, graphical visualizations, and animations, particularly focusing on the design of checkerboard metasurfaces for RCS reduction and metasurface printed antennas. These resources are invaluable for both teaching and self-study.

Chapter 16: Artificial Impedance Surfaces offers an in-depth exploration of AIS and their diverse applications, focusing on the control and broadband RCS reduction using checkerboard designs, as well as optimizing antenna fundamental parameters like input impedance, directivity, realized gain, and amplitude radiation pattern. This chapter delves into the practical applications and theoretical aspects of AIS, including the study of leaky-wave antennas utilizing 1-D and 2-D polarization diverse-holographic high impedance metasurfaces for advanced radiation control and optimization. It extensively covers applications in various antenna types such as monopole, horizontal dipole, circular loop, aperture antenna, microstrip array, and surface-wave antennas, emphasizing their use in high-gain printed leaky-wave antennas. These topics not only underscore the theoretical aspects but also provide practical application perspectives, making the book an essential resource for advanced studies.

Chapter 16: Artificial Impedance Surfaces Overview:

3. COMMENTS

3.1. Personal Reflections

Advanced Engineering Electromagnetics has significantly influenced my academic path since 2001. It has consistently featured in my teaching modules, owing to its thorough treatment of electromagnetic engineering topics.

My interaction with Professor Balanis at the AP/S-URSI 2023 symposium was enlightening. We discussed the impact of his book and its Turkish translation, a project I contributed to as part of a team of Turkish academicians and researchers (Balanis, 2021b). Balanis expressed appreciation for our translation efforts and further supported our endeavors by generously providing additional materials for teaching and research, underscoring his dedication to the field of electromagnetics education.

3.2. The Book’s Impact on Electromagnetics Education

The book's impact is evident in its over 13,000 citations in scientific articles, emphasizing its role as a primary reference in graduate-level electromagnetics education. It's particularly useful in electrical engineering, covering a broad range of topics relevant to modern naval and civilian electromagnetics applications.

4. CONCLUSION

Reflecting on Balanis' journey from Greece to the USA (Balanis, 2023), one can't help but be inspired by his indelible mark on electromagnetics and antenna theory, significantly impacting electromagnetic research and education. The upcoming AP/S-URSI 2024 symposium (IEEE AP-S/URSI, 2024), which will honor Professor Balanis on his 85th birthday, is a testament to his ongoing influence in the field.

The third edition of his book, with its focus on emerging technologies like artificial impedance surfaces, ensures its continued relevance in a technologically evolving world. It's more than an update; it represents Balanis' lifelong commitment to advancing electromagnetic education and research, making it an essential resource for students and researchers in advanced engineering electromagnetics.

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