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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), poised for a January or February 2024 release in both electronic and hard copy formats, represents the culmination of extensive academic endeavors. My opportunity to review this edition stems from my access to materials provided by Professor Balanis, combined with my experience in the Turkish translation team for the second edition (Balanis, 2021a). This latest edition preserves the core strengths of its predecessors while integrating notable advancements. A highlight is the addition of a new chapter on artificial impedance surfaces (AIS), which brings to the forefront contemporary and advanced electromagnetic technologies, including the increasingly relevant field of metasurfaces.

The review delves into the technical improvements and educational impact of the third edition, showcasing its relevance for both naval and civilian electrical engineering education. It assesses the expanded content and updated methodologies of the third edition, highlighting its pivotal role in advancing the study and application of electromagnetic theory in various fields like antennas, microwave circuits, radio frequency, optical communications, and wireless technologies.

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.

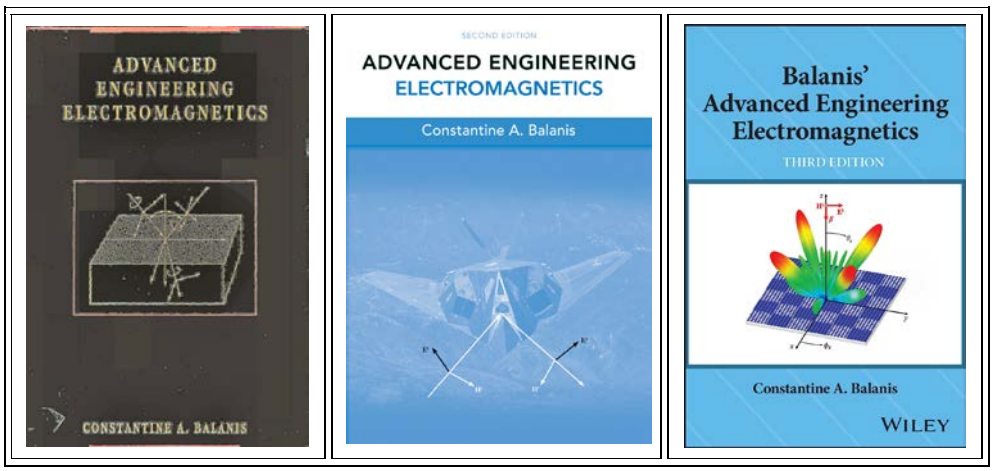

Figure 1. *The Evolution of Advanced Engineering Electromagnetics: 1st Edition, 2nd Edition, 3rd Edition.*

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

Since 2001, "*Advanced Engineering Electromagnetics*" has been a foundational resource in my academic endeavors, complementing various other materials in both research and teaching. Its comprehensive coverage of electromagnetic engineering topics has made it an indispensable component of my educational curriculum.

During the AP/S-URSI 2023 symposium, I had the opportunity to engage in a meaningful dialogue with Professor Balanis. We examined the extensive impact of his book, as well as its translation into Turkish, a project to which I contributed alongside a team of esteemed Turkish academicians and researchers (Balanis, 2021b) (Balanis, 2021c). Professor Balanis acknowledged our efforts in the translation project and further enhanced our academic pursuits by providing additional resources for teaching and research. This gesture exemplifies his unwavering commitment to advancing electromagnetic education.

3.2. The Book's Impact on Electromagnetics Education

This textbook has garnered over 13,000 citations in scientific literature, underscoring its status as a fundamental resource in graduate-level electromagnetics education. Its comprehensive scope encompasses a wide array of topics pertinent to both naval and civilian applications in the field.

4. CONCLUSION

The third edition of "*Balanis' Advanced Engineering Electromagnetics*" stands as a testament to the ever-evolving landscape of electromagnetic technology, particularly with its emphasis on contemporary topics like artificial impedance surfaces. This edition transcends beyond being a mere update, reflecting a commitment to the progression of electromagnetic education and research. It serves as a vital resource for both students and researchers in the field of advanced engineering electromagnetics.

In the context of Professor Balanis' career trajectory from Greece to the United States (Balanis, 2023), his substantial contributions to electromagnetics and antenna theory (Balanis, 2016) have been widely recognized, profoundly influencing research and education. The upcoming special session at the AP/S-URSI 2024 symposium (IEEE AP-S/URSI, 2024), commemorating his 85th birthday, underscores the enduring impact of his work within the electromagnetic community.

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