

Electroacoustics

Mendel Kleiner, CRC Press/Taylor & Francis Group, Boca Raton, (2013), 585 pp., 119.95 USD, ISBN 978-1-4398-3618-7.

This book is a thorough compendium of electroacoustic principles and applications and is a welcome addition to the literature on this topic. Electroacoustic books have not been published as frequently as books in other areas of acoustics. Similar books by Geddes, Hunt, Rossi, Merhaut, and Olson are out-of-print, dated, or do not present the breadth of content as does this book. I have used the late W. Marshall Leach's book *Introduction to Electroacoustics and Audio Amplifier Design* in my *Electroacoustics* class and it has been generally well-received by students. Kleiner's book can be considered the new standard.

Electroacoustics comprises 25 chapters arranged in a logical sequence starting with acoustic and transducer fundamentals, progressing to microphones, loudspeakers, and lastly headphones. Seven appendices covering related topics round out the book. A list of symbols and abbreviations – an essential feature for any textbook – appears at the beginning. Chapters contain review questions, problems and references.

The book approach includes basic theory and applications with a particular emphasis on electromechanical and electroacoustical analogies to explain transducer operating principles. Key equations are presented without derivation; applications are succinctly explained. These comments should not be viewed as criticisms given the wide range of topics the book covers.

The first two chapters are introductory. Chapters 3 and 4 cover sound propagation in air, and membranes and plates.

Basic electric circuits, electromechanical and electroacoustical analogies and the conversion between the two are covered in Chapters 5 through 8. Practical examples include end correction, acoustic resistance and filters.

Chapters 9 and 10 review basic transducer operation, radiation and impedance fundamentals for simple sources, membranes and plates. Besides theoretical considerations, principles of microphone and loudspeaker design including capacitive, piezoelectric and magnetostrictive devices are described.

Loudspeaker interaction in rooms is the subject of Chapter 11, with emphasis on radiation impedance and relative power output modifications for sources near boundaries. Room modes are briefly covered while large room acoustics is not.

Chapter 12 is a lengthy chapter on source directivity focusing on the frequency-domain approach. The time-domain approach is reviewed in Appendix D.

Monopole, piston in a baffle, near and far field response and transducer arrays are described.

Microphones are covered in Chapters 13 and 14. The former chapter deals with how microphones affect the sound field they are placed in and the design of microphones to create different directivity patterns. The latter Chapter 14 reviews microphones of all kinds including pressure and pressure gradient types with examples of capacitive, dynamic and piezoelectric microphones.

Chapters 15 through 23 address loudspeakers for high fidelity and sound reinforcement applications.

Chapter 15 reviews the operating principles of the standard cone electrodynamic driver, both in terms of describing the various component parts and presenting electroacoustical circuits for this device. Loudspeaker enclosures are covered in Chapters 16 through 18. Infinite baffle and sealed enclosures are described in Chapter 16. Ported, passive radiator and bandpass enclosures are covered in Chapter 17. Lastly, transmission line enclosures are reviewed in Chapter 18.

Electroacoustic horns are the subject of Chapter 19. Webster's equations, simple exponential horns, and more complicated horn geometries such as conical, hyperbolic and tractrix types are described. Horn directivity is briefly reviewed with emphasis on multi-cell horns. Horn line arrays, low-frequency horns, and compression drivers are all too briefly covered. Expanding these topics would improve the utility of this book.

Chapter 20 presents an overview of gradient loudspeakers used to create bi-directional radiation patterns for directivity control. I have not seen this topic covered in other electroacoustics books.

Loudspeaker drivers using flexible membranes, based on distributed mode radiation characteristics, are covered in Chapter 21. These loudspeakers induce uniformly distributed vibration modes in a membrane or lightweight panel through an electroacoustic exciter. The concept of driving point impedance is discussed since this principle is used to excite the membrane into vibration.

Chapter 22 summarizes multi-way loudspeakers that use several drivers interconnected by a crossover network. A scant four pages are devoted to crossover networks. More information on crossovers, perhaps as a separate chapter, would help the reader better understand this important feature of loudspeaker design.

Active loudspeakers that include an integral power amplifier, analog or digital signal processing, and in some cases, feedback control is the subject of Chapter 23.

Headphones – one of the few growth areas in the audio industry – are covered in Chapter 24. Electrodynamic, electromagnetic and electrostatic headphones are reviewed considering the acoustic

environment they are used in and basic design considerations. Sufficient information is presented; however the gold standard for this topic still remains the 2001 Borwick book, *Loudspeaker and Headphone Handbook*.

Chapter 25 covers high-frequency transducers, with a particular emphasis on basic design considerations for piezoelectric devices.

The book concludes with seven appendices: Introduction to Electric Components and Classic Circuit Theory (Appendix A); Filters and Filter Functions (Appendix B); Magnetic Fields and Forces (Appendix C); Time-Domain Approach to Directivity (Appendix D); Sound Absorbing Materials (Appendix E); Resonance in Boxes and Rooms (Appendix F); and Level Differences (Appendix G). All are relevant to specific topics in the book.

Aside from the criticisms noted above, the only other issue I have with *Electroacoustics* is the brief coverage

given to line array sources. Presently there are nearly 50 line array loudspeaker types in the professional sound reinforcement market. Hopefully a future edition will expand on the coverage in Chapters 12 and 19 to include descriptions of passive and digital directivity controlled line array loudspeakers.

In summary, I found *Electroacoustics* to be a very readable and informative book. Despite my criticisms, the book provides an excellent summary of electroacoustic principles and applications. It will serve as an excellent textbook for an electroacoustics class or a resource for product designers.

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