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Fundamentals of Electronics: Book 3

Active Filters and Amplifier Frequency Response

Thomas F. Schubert, Jr.
Ernest M. Kim

SYNTHESIS LECTURES ON DIGITAL CIRCUITS AND SYSTEMS

Mitchell A. Thornton, *Series Editor*

Fundamentals of Electronics
Book 3
Active Filters and Amplifier Frequency Response

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SYNTHESIS LECTURES ON DIGITAL CIRCUITS AND SYSTEMS #49

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ABSTRACT

This book, *Active Filters and Amplifier Frequency Response*, is the third of four books of a larger work, *Fundamentals of Electronics.* It is comprised of three chapters that describe the frequency dependent response of electronic circuits. This book begins with an extensive tutorial on creating and using Bode Diagrams that leads to the modeling and design of active filters using operational amplifiers. The second chapter starts by focusing on bypass and coupling capacitors and, after introducing high-frequency modeling of bipolar and field-effect transistors, extensively develops the high- and low-frequency response of a variety of common electronic amplifiers. The final chapter expands the frequency-dependent discussion to feedback amplifiers, the possibility of instabilities, and remedies for good amplifier design.

Fundamentals of Electronics has been designed primarily for use in an upper division course in electronics for electrical engineering students and for working professionals. Typically such a course spans a full academic year consisting of two semesters or three quarters. As such, *Active Filters and Amplifier Frequency Response*, and the first two books in the series, *Electronic Devices and Circuit Applications*, and *Amplifiers: Analysis and Design*, form an appropriate body of material for such a course.

KEYWORDS

active filters, frequency response, Bode plot, filter, Butterworth, low-pass, high-pass, band-pass, band-stop, Chebyshev, switched capacitor, gain margin, phase margin, cutoff frequency, high frequency transistor modeling, Miller's theorem, capacitive coupling, Cascode, Darlington, multipole feedback frequency response, Nyquist stability, dominant pole compensation, compensation networks

Fundamentals of Electronics

Book 3

Active Filters and Amplifier Frequency Response

Synthesis Lectures on Digital Circuits and Systems

Editor
Mitchell A. Thornton, ***Southern Methodist University***

The *Synthesis Lectures on Digital Circuits and Systems* series is comprised of 50- to 100-page books targeted for audience members with a wide-ranging background. The Lectures include topics that are of interest to students, professionals, and researchers in the area of design and analysis of digital circuits and systems. Each Lecture is self-contained and focuses on the background information required to understand the subject matter and practical case studies that illustrate applications. The format of a Lecture is structured such that each will be devoted to a specific topic in digital circuits and systems rather than a larger overview of several topics such as that found in a comprehensive handbook. The Lectures cover both well-established areas as well as newly developed or emerging material in digital circuits and systems design and analysis.

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Preface

In the previous two books of this series, all electronic circuit operation was considered to be either at near-zero frequency or in the "midband" region of operation. The midband range of frequencies, vitally important to amplifier discussions, is characterized by two basic simplifying assumptions:

- The midband frequencies are large enough so that discrete circuit capacitors appear to have negligible impedance with respect to the resistances in the circuit, and
- The midband frequencies are small enough so that the active elements (transistors, OpAmps, etc.) appear to have frequency-invariant properties.

It is the purpose of this book to explore the variation of circuit behavior over the entire range of frequencies. In addition to exploring frequency dependence, the time domain equivalence of these effects is explored.

A review of the characteristics of ideal filters and frequency response plots leads into the design of active filters. Active Butterworth and Chebyshev filter design is discussed in this section using OpAmps as the active circuit elements. Discussion of passive filters and filters with other active elements is saved until the chapter in Book 4 on communication circuits. The frequency response limitations of OpAmps provide an introduction to limitations common in other devices.

Transistor amplifier frequency response is first discussed through the effects of coupling and bypass capacitors. Once those principles are mastered, modified models for the diode, BJT and FET are introduced to model the high-frequency limitations of common devices and the result of these limitations on the frequency response of amplifier circuits. The effect of feedback on frequency response is initially presented as a special case of stabilization: here stabilization against variation in element value change due to frequency. Feedback effects on pole migration is emphasized. Compensation against possible instabilities or oscillations is explored extensively.

In this book, amplifier oscillations are considered an undesirable condition. In the next book of this series, these instabilities are explored in the design of linear oscillators.

Thomas F. Schubert, Jr. and Ernest M. Kim
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