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## Preface

Filters are essential subsystems in a huge variety of electronic systems. Filter applications are innumerable; they are used for noise reduction, demodulation, signal detection, multiplexing, sampling, sound and speech processing, transmission line equalization and image processing, to name just a few. In practice, no electronic system can exist without filters. They can be found in everything from power supplies to mobile phones and hard disk drives and from loudspeakers and MP3 players to home cinema systems and broadband Internet connections.

This textbook introduces basic concepts and methods and the associated mathematical and computational tools employed in electronic filter theory, synthesis and design. Since the approximation problem must be solved before a filter can be designed, a significant part of the book is concerned with approximations in a manner that allows deep understanding and easy generalization. The approximation procedure uses the filter specifications to derive a circuit function, from which the electronic filter circuit can then be synthesized. The synthesis method to be used in order to derive an electronic circuit from a mathematical circuit function depends on the technology which is to be employed for the final implementation of the filter. Synthesis methods are therefore dependent on the technologies currently available and change as technology evolves. In this book, synthesis methods have been restricted to the classical passive and active-RC cases, which are excellent robust paradigms with high didactic value. More recent technologies like OTA-C, log-domain, current conveyors based circuits and so on are not presented as they are overly specialized for a general filter textbook which is aimed mainly at supporting students of undergraduate filter courses.

Most of the material of the book can be taught as part of undergraduate courses on filters. Chapter 1 is a general introduction to filter concepts and design methods and provides a basic background to these as well as the common language for filter synthesis and design. Chapter 2 deals with the classical polynomial approximations (Butterworth and Chebyshev) that lead to all-pole lowpass transfer functions without zeros. It also introduces the recently documented Pascal approximation. In Chap. 3, rational approximations are presented. Rational approximations, such as the inverse Chebyshev, lead to lowpass transfer functions with  $j\omega$ -axis zeros and gain or attenuation ripple in the stopband. Chapter 4 is exclusively devoted to a special rational approximation, the elliptic approximation, not only for its importance, but also because it has not been given the full attention it deserves in the literature due to the complicated mathematics involved. In this chapter, all mathematical formulae are provided and the corresponding computational tools are explicitly presented.

Chapters 2–4 apply to lowpass filters. Chapter 5 presents the transformations that can be used for other types of filters, i.e. highpass, bandpass and band-reject filters. Chapter 6 provides an introduction to passive filters, while the actual design of such filters is dealt with in Chap. 7. The active-RC simulation of passive ladder filters is presented in Chap. 8.

Operational amplifiers and first and second order circuits are presented in Chaps. 9 and 10, while in Chap. 11 some specific filter synthesis mathematics is presented. Finally, Chap. 12 covers the synthesis of RLCM one-port circuits, used extensively in passive filter design.

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Athens, Greece

Hercules G. Dimopoulos



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