FOREWORD

The basics of filter design theory have not changed for over half a century. Thus, irrespective of whether the prevailing or available technology favors a particular kind of filter realization; e.g., passive LCR, active RC, digital, or switched-capacitor, the initial steps from filter specifications to actual design are based on the fundamental work of such pioneers as O.J. Zobel, R.M. Foster, W. Cauer, O. Brune, S. Darlington, and many others. The resulting design theories, foremost among them insertion-loss theory, have resulted in an almost ritualistic procedure for the preliminaries of a filter design. This consists of transforming the given specifications; e.g., maximum-passband and minimum- stopband loss, transition-frequency band, impedance level, and so on, into either a transfer function in s or z (depending on whether the filter is to operate in continuous or discrete time), or into an LC filter structure. In doing so, the designer has the choice of filter type; e.g., Chebyshev, Butterworth, Elliptic, Bessel, and many more, this choice being determined by such factors as the filter order (which is generally related to the filter cost), group delay, inband ripple, band-edge selectivity, ease of tuning, and various other application-dependent requirements. Having made these decisions, and taken into account the given specifications, the filter designer then either consults a book of filter tables, or a corresponding computer program, and obtains the abovementioned transfer function or filter topology. At this point, the "preliminary design rit-

ual" ends and the designer must either make some difficult choices in terms of available technology, or comply with the technological demands of the system to be designed; i.e., IC design, discrete-component active RC or LC design, digital signal processor (DSP), monolithic crystal, surface acoustic wave (SAW), mechanical, and so on.

This book on Advanced Filter Design by M.D. Lutovac, D.V. Tosic and B.L. Evans does away with what I have called the "preliminary design ritual," and opens up completely new vistas in basic filter design, regardless of the technology. The authors show that the conventional filter types (e.g., Butterworth, Chebyshev, Elliptic) are not unique solutions to a given set of specifications; much rather they are special cases of a *continuum of solutions*, all of which, while satisfying the specifications, permit tradeoffs to be made between a variety of optimizations that were considered inaccessible and unachievable in the past. Thus, where, for example, the poles and zeros of an elliptic filter, meeting certain gain and phase demands, were considered immutable in the past, this book can provide a new set of poles and zeros (with possibly an increased order by one or, rarely, two) which they call the "minimum Q" solution, whose poles lie not on an ellipse but on a semicircle (as with a Butterworth filter) and *whose dominant pole Q is significantly lower than that of the original elliptic filter*. Minimum pole Q, of course, implies lower sensitivity to component tolerances and, as a rule, lower thermal noise. However, this is only one of the many optimization options that this remarkable book supplies. It can provide a variety of different solutions (still meeting specs, of course, and with barely an increase in filter order). Thus, for example, it can provide a solution for minimal deviation from linear phase, or for specified group delay while maintaining minimal filter order, or, in the case of discrete-time filters, for zero-phase, or for a multiplierless elliptic IIR filter structure. These are merely examples of the unprecedented versatility in filter design that this new and unique book supplies. Since the essence of the book is to loosen the rigidity, in terms of options and optimization, that the previous "preliminary design ritual" demanded, it can be used as a new versatile preliminary design routine for any kind of subsequent filter realization—be it, for example, LC, active RC, digital or switched-capacitor. Indeed, the authors demonstrate their new and versatile design technique in conjunction with all of these filter types, and many more.

So how do the authors manage the extraordinary accomplishment of liberating themselves from the old classical preliminary design ritual, and why has this not been done long ago? The answer is simple. Beside some exceptionally elegant and creative mathematical stratagems (e.g., accurate replacement of Jacobi elliptic functions by functions comprising polynomials, square roots, and logarithms), they utilize high-power computer programs and optimization routines that were not previously available. Foremost among these are optimization routines carried out with symbolic analysis by *Mathematica*, and the advance filter design software of MATLAB. The exceptional combination of these highly advanced, modern and sophisticated design programs, together with a remarkable mathematical and algorithmic acumen, and an indepth and profound understanding of classical and modern filtering and signal-processing techniques, has produced in this book a new, and, without exaggeration, revolutionary method of filter design, that will have a pivotal effect on the way filter design is carried out in the future. This does not detract one bit from the monumental achievements of the previous pioneers in network theory and filter design; it merely reflects the fact that the modern

computing tools available today, when in the hands of the right experts in mathematics, algorithmics, and network theory, can change dramatically a discipline such as filter theory and design, which was previously considered complete, definitive, and immutable. It is fortunate that the right ingredients come together in the form of these three talented authors, combined with the best that modern computer technology and algorithmics can supply (i.e. MATLAB and *Mathematica*) to produce a book and computer-software for filter design that will change the field in a profound way that could not have been anticipated but a few years ago. With the appearance of this book, filter design may never be the same again.

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