SOLVING THE APPROXIMATION PROBLEM FOR NARROWBAND BANDPASS FILTERS WITH EQUAL-RIPPLE PASSBAND RESPONSE AND ARBITRARY PHASE RESPONSE

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Abstract

A practical method is presented for solving the approximation problem for narrowband bandpass filters with equal-ripple passband response and arbitrary phase response. The method determines the element values of the low-pass prototype filter and is based on the use of generalized Chebyshev rational functions with arbitrary choice of transmission zero locations. The use of both real frequency and complex frequency transmission zero locations is considered. Results of trial design problems are presented and are related to previous design results to illustrate practical realization and performance limitations

Several recent papers[1,3] have described how the use of non-adjacent couplings in coupled resonator filters can be used to advantage for simultaneously obtaining specified amplitude and phase characteristics. The work of Rhodes[1,2] provides an elegant solution for certain types of problems, but is heavily biased towards providing a specified phase rather than a specified amplitude response. The filters described by Atia and Williams[3] provide improved amplitude response at the expense of band-edge phase response by allowing finite poles of attenuation. However, the latter authors have not presented a method for solving the general filter approximation problem.

While the general procedure described by Rhodes[2] is theoretically capable of providing any possible response characteristic, in practice, it is found that the stopband amplitude response is extremely sensitive to very small changes in the specified passband phase response. Thus, it becomes extremely difficult to achieve designs with specified stopband poles of attenuation. The above sensitivity can be circumvented by the use of a method based on generalized Chebyshev rational functions. This method has a disadvantage over the procedure described by Rhodes in that repeated numerical Hurwitz factorization and a high degree of numerical accuracy is required during the design process. However, by using a well-known transformed variable approach[4] and almost any time-share computer terminal, complex designs can be achieved in a matter of minutes at quite low cost.

The basic design process using generalized Chebyshev rational functions is not new, being described in essence by Bennett[5] more than two decades ago. The procedure has been used for generalized amplitude type filters by numerous authors and has previously been applied to the design of microwave filter structures[6]. The above authors have used the procedure to achieve a cascade network realization that is often not practical for realizing narrowband bandpass response characteristics. By using the Chebyshev rational function approach at the approximation stage, and non-adjacent couplings in the network realization stage, practical filter designs with or without finite poles of attenuation are readily obtained.

This paper summarizes the design procedure described above and discusses practical realization and performance limitations. The approach given readily yields networks whose response matches those described by both Rhodes and Atia and Williams. For a given order filter characteristic, the techniques described allow the realization of all possible filter response characteristics having an equal ripple passband response.

References

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