DESIGN OF TWO-DIMENSIONAL DIGITAL FILTERS USING TRANSFORMATION

A thesis submitted to the
Indian Institute of Technology, Delhi
for the award of the degree of

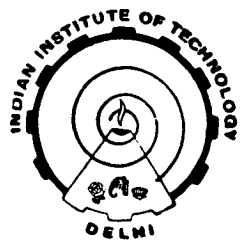
DOCTOR OF PHILOSOPHY

in

Electrical Engineering

by

M. SUDHAKARA REDDY



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JULY 1987

DEDICATED

TO

MY PARENTS

CERTIFICATE

This is to certify that the thesis entitled, "**Design of Two-Dimensional Digital Filters Using Transformation**" being submitted by M. Sudhakara Reddy to the Department of Electrical Engineering, Indian Institute of Technology, Delhi, for the award of the degree of **Doctor of Philosophy** is a record of bona fide research work carried out by him under our supervision and guidance and in our opinion, it has reached the standard fulfilling the requirements of the regulations relating to the degree.

The results contained in this thesis have not been submitted to any other University or Institute for the award of any degree or diploma.

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ACKNOWLEDGMENT

It is a privilege for me to have been associated with Professor S.N. Hazra and Professor S.C. Dutta Roy, my supervisors, during the course of this research work. I have been greatly benefited by their valuable suggestions and ideas, keen interest and constant encouragement. It is a great pleasure to acknowledge my debt of gratitude to both of them.

I am grateful to the authorities of Sri Venkateswara University, Tirupati, for sponsoring me under the Quality Improvement Programme for undertaking this research work, and to the Government of India for providing the scholarship during the course of this work.

I appreciate my wife Saroja and children Anitha and Suneel for their patience and understanding throughout the period of this work.

Finally, I thank Mr. P.M.Padmanabhan Nambiar for typing the manuscript neatly and Mr. R.P. Kapoor for the preparation of drawings.

M. Sudhakara Reddy

ABSTRACT

Two-dimensional (2-D) digital filters are widely used in processing of images and geophysical data, and in numerous other applications. One of the techniques for designing 2-D filters with piecewise constant frequency response is to transform a prototype one-dimensional (1-D) filter using a suitable transformation function. The technique is simple because design of the filter with specified frequency response is carried out in one-dimension where a variety of well established and optimal design techniques are available for both FIR and IIR filters. The transformation technique has been established as a powerful method, particularly for the design of 2-D FIR filters because of several advantages. The transformation for obtaining a 2-D FIR filter from a 1-D filter was first proposed by McClellan, and later generalized by Mersereau et al. Various techniques exist in the literature for choosing the coefficients of the first-order McClellan transformation so as to approximate a specified passband boundary. However, some of these techniques are rather involved while the others have either limitations or drawbacks. Therefore, a simple technique for choosing the coefficients which can approximate the desired passband boundaries of a large class of 2-D filters with a high degree of accuracy will be very welcome.

The major part of the research work presented in this thesis concerns the determination of the coefficients of the first-order McClellan transformation so that the cut-off frequency of the 1-D filter maps onto a contour in the two-dimensional frequency plane which approximates the desired passband boundary of the 2-D filter. Firstly, an analytic technique has been proposed for choosing the coefficients of the transformation so as to approximate a circular or an elliptic contour. The technique is simple and the accuracy of approximation is as good as that obtained by an optimization procedure reported earlier in the literature. However, the technique, in general, does not approximate the contour in equiripple sense. Therefore, the Remez algorithm has been used to obtain equiripple approximation. The types of contours considered are the passband boundaries of the circularly symmetric, elliptically symmetric and α^{o}-fan filters. It has been shown that, for these filters, the Remez algorithm converges rapidly and that the procedure is efficient. The equiripple approximation is also extended to a number of passband boundaries for the design of circularly and elliptically symmetric multiband filters. Finally, the analytic technique is extended to the design of 2-D filters whose cutoff boundary is an ellipse of arbitrary orientation.

The thesis also includes a brief investigation of the design of 2-D IIR filters by transformation, and implementation of a first-order 2-D all-pass function. A method for the design of 2-D IIR filters using first-order all-pass separable transformation function is presented. The method is an improvement over a recently reported technique. All-pass filters are used in cascade with IIR filters to improve the overall phase response of the system. A new structure has been proposed for the realization of a 2-D first-order all-pass filter with five multipliers and two delays. This is an improvement over an existing implementation using six multipliers and two delays.

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