ON THE DESIGN OF
ANALOG & DIGITAL DIFFERENTIATORS

A thesis submitted to the
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by

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D E D I C A T E D

T O

M Y P A R E N T S

C E R T I F I C A T E

This is to certify that the thesis entitled," ON THE DESIGN OF ANALOG AND DIGITAL DIFFERENTIATORS", being submitted by Balbir Kumar 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 my supervision and guidance and that in my 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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A C K N O W L E D G E M E N T

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A B S T R A C T

The research work presented in this thesis is connected with new approaches for the design of differentiators for analog as well as digital systems. Efficient results have been achieved by insisting on mathematical exactitude in the investigations.

In analog filters, various configurations of active as well as passive differentiators are available. However, no concrete results are known with respect to optimum, passive and realizable differentiators. An analysis to highlight the intrinsic constraints on realizability and performance of such differentiators has been carried out in this thesis.

Digital differentiators (DD) constitute an important class of digital processors. The DDs characterized by finite impulse response (FIR) are unconditionally stable and can be designed for linear phase responses. The various available design techniques including the most popular one, viz. minimax relative error (MRE) approximation [7] , are either inefficient or use time consuming optimization algorithms to compute the weighting coefficients required in the structures. Moreover, these approximations cannot be successfully adopted for DDs required to perform over a limited frequency range. In the present research, attention has been focussed on a different type of designs viz. maximally linear DDs, which

are suitable for operation over a limited frequency range at low, midband and high frequencies. Mathematical formulas for computing the weighting coefficients for the DDs have also been derived.

In numerous applications, one requires a variable frequency/bandwidth DD. No technique to realize such digital differentiators is known. It has been shown, in the present work, that maximally linear DDs can achieve such operation in an elegant manner.

The digital differentiators, the digital Hilbert transformers (DHT) and the half-band low-pass filters (1/2-LPF) apparently seem to be closely related to each other. A composite and complete picture of the inter-relationships between the DDs, DHTs and 1/2-LPFs has been portrayed in this thesis. This enables the differentiator designs to be adopted to the design of the DHT and 1/2-LPF.

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