

nonlinear circuits handbook

designing with analog function modules and IC's

by

**The Engineering Staff of
Analog Devices, Inc.**

Edited by

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PREFACE

This book's origins lie in the solid ground of Analog Computing theory and practice. Until recently, the design and use of circuit configurations based on the conscious employment of nonlinear analog computing elements and formulations has been the recon-dite province of a few diehard experts in specialized areas of application.

Now this area of endeavor, so lately in the shade of digital technology, is becoming increasingly illuminated as the sparks thrown off by the commercial availability of modular devices with improved performance and decreased cost, complexity, and size, ignite the tinder of latent applications. It is our present objective, stemming from motives that range from a sense of technological mission to some that might be considered far more crass (yet eminently human), to provide an agency by which these small flames might be fanned into a bright and cheerful blaze, by the light of which all users of electronic circuits might gain useful knowledge, and benefit by a rediscovery of analog technology.

There are books available on analog computing and operational-amplifier applications, and there exists a smattering of publications on nonlinear circuitry and its applications; yet it is all but impossible to find a single source that combines information on principles, circuitry, performance, specifications, testing, and application of the class of devices specifically designed to be purchased for use in nonlinear applications. It is to this task that we have addressed ourselves in preparing this volume. Beyond the simple provision of information, however, we have felt it necessary to seek to communicate some of our excitement over the possibilities of analog nonlinearity and its often-cooperative role in systems involving both digital and analog data.

To make it all fit, we have had, in some cases, to sacrifice: rigor for vigor, specific details for general principles (and hints of possibilities), and evenhanded treatment for a particular orientation — that of a major manufacturer of the devices in question. In each case, though, the sacrifice is offset by a pragmatic gain, for the reader as well as for ourselves. For example, the citing of specific instances of commercially-available entities (manufactured by Analog De-

vices) tends to impart a sense of reality and practicality that a more-austere orientation might lack.

Furthermore, to avoid imposing today's technology (in this rapidly-changing field) on tomorrow's reader, we have repeatedly urged, and here reiterate, that the interested reader arm himself with Product Guides, data sheets, application notes, and other propaganda from all responsible and innovative manufacturers of non-linear circuits, and seek to be on their mailing lists.

It is our hope that this volume will meet whatever need the reader brings to it: education for the tyro, ideas for the experienced practitioner, gap-filling for the engineer or scientist whose competence lies in other fields, practical advice for the theorist, and a source of ready reference for all.

HOW TO USE THIS BOOK

The prospective users of this book, whether students or experienced design engineers, naturally have a wide variety of backgrounds, interests, and needs. Although it is not expected that any reader will be totally satisfied, all who seek enlightenment, ideas, or guidance on matters having to do with nonlinear analog circuits should find something of value.

Whatever his interest, the reader will find the self-explanatory structure of the book laid bare in the Table of Contents, which every reader should explore thoroughly before proceeding further.

One can read through this book sequentially, but it is not necessary to do so; browsing is encouraged. Each unit is essentially self-contained, with occasional references to importantly-related units. Though this involves some redundancy, it also enables a topic to be approached from several points of view. The encyclopedic Index should be useful when exploring any topic in depth.

The Bibliography is a brief and eclectic assortment of sources of information on various topics covered within the book. Each item is chosen, either because of its specific practical value or timely interest, or because it in turn has a reference section that will "fan out" and give the reader large coverage from a small base. Design engineers should use this Handbook in conjunction with

data sheets on specific products of interest, and with the most recent edition of the comprehensive *Analog Devices Product Guide*. In addition to its up-to-date contents and much data (with prices) on specific products, it also contains a wealth of technical information on related subjects and products, not all of which is duplicated in these pages.

Readers are urged to communicate to us their comments and suggestions for future editions of this Handbook, as to content, *errata*, omissions believed significant, and new applications ideas.

ACKNOWLEDGEMENTS

The writing of this book was a cooperative effort by the engineering staff at Analog Devices. Contributions have come from a wide distribution of Divisions and Departments, and reflect the efforts of design engineers, applications engineers, marketing engineers, test engineers, and others.

Major contributors include Lewis Counts (Chapters 3-2, 3-3, 3-6, and 3-7), Fred Pouliot (Chapters 4-1, 4-2, and 4-3), John Cadogan (Chapter 3-1), Barry Hilton (Chapter 3-5), and Walter Borlase (Chapter 4-4). Chapter 3-4 was written by Dr. Modesto A. Maidique, Stanley Harris, Richard Wagner, and Fred Mapplebeck. Besides the writing of a portion of Chapter 3-4, many good ideas and useful comments, plus advice and encouragement, were supplied by Barrie Gilbert. Important contributions were also provided by Richard Burwen, Fernando Romero, and Donn Blomerth.

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The book was prepared by our Publications department, under Marie Etchells, profusely illustrated by Ernest Lehtonen, Penny Brian, Eileen Solari, Shu Ngon Chau, and Joseph Furbush; much of the typesetting was done by Camilla O'Brien. A goodly portion of the manuscript was typed by Edna Godfrey.

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and *Electronic Design*, with yeoman assistance from Richard Goldberg.

Organization, editing, many ideas, and much of the writing were furnished by the undersigned, who also accepts the responsibility for any shortcomings.

January 1, 1974
Norwood, Mass.

D. H. Sheingold

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