FUNCTIONAL CIRCUITS AND OSCILLATORS

---

by

HERBERT J. REICH

Department of Electrical Engineering
Yale University

D. VAN NOSTRAND COMPANY, INC.

PRINCETON, NEW JERSEY

TORONTO LONDON

NEW YORK

D. VAN NOSTRAND COMPANY, INC.
120 Alexander St., Princeton, New Jersey (*Principal office*)
24 West 40 Street, New York 18, New York

D. VAN NOSTRAND COMPANY, LTD.
358, Kensington High Street, London, W.14, England

D. VAN NOSTRAND COMPANY (Canada), LTD.
25 Hollinger Road, Toronto 16, Canada

Published simultaneously in Canada by
D. VAN NOSTRAND COMPANY (Canada), LTD.

PRINTED IN THE UNITED STATES OF AMERICA

This Book Is Dedicated
to All Who Have Participated in Its Preparation

PREFACE

A large portion of this book deals with the theory, characteristics, and applications of negative-resistance circuits and with the theory and characteristics of sine-wave oscillators. The book might have been restricted to these subjects and entitled, "Oscillators and Negative-Resistance Devices." Because many negative-resistance devices find their principal applications as counters, memory devices, and generators of pulses and nonsinusoidal waves, it seemed desirable to extend the coverage to other functional circuits, including summing circuits, differential amplifiers, differentiators, integrators, clippers, gates, and nonlinear-circuit simulators.

Much has been written on the subject of negative-resistance circuits and their applications. No previous attempt appears to have been made, however, to analyze generalized basic negative-resistance circuits and to derive principles and criteria that can be conveniently used in the synthesis of almost all presently-known practical negative-resistance circuits and devices and the bistable, astable, monostable, and sine-wave-oscillator circuits based upon them. When these principles and criteria are understood, it is a simple matter to synthesize negative-resistance circuits using any type of active element and to determine the ports at which the circuits have voltage-stable current-voltage characteristics, and those at which they have current-stable characteristics. The circuit elements that must be added in order to convert a particular negative-resistance circuit into a bistable, astable, monostable, or sine-wave-oscillator circuit can then be readily determined.

It is advantageous to consider all feedback oscillators from the point of view of a basic generalized circuit consisting of a broadband amplifier and a frequency-selective feedback network. In this manner a criterion for steady-state oscillation of all feedback oscillators may be derived in terms of the y and z parameters of two-port networks. The criterion may be readily applied to the analysis of almost all commonly-used feedback oscillators incorporating tubes, transistors, or other active elements. This approach affords an insight into the causes of frequency instability and suggests ways of increasing stability. It is also helpful in the synthesis of new or modified circuits. Another important aspect of oscillator theory treated in this book is the mechanism of amplitude stabilization by the use of circuit nonlinearities.

The desire to minimize the space devoted to routine mathematical deriva-

tions may tempt an author to rely unduly upon the statement, "It may be readily shown that . . . ," when, in truth, the proper procedure is obvious only after the analysis in question has been performed. In order to eliminate mathematical details without straining the ingenuity of the reader unnecessarily, many proofs and derivations throughout the book have been presented in the form of problems in which a general method of procedure is outlined.

It is hoped that this book may find application both as a text and as a reference and that it will prove useful in the synthesis of new circuits to serve specific functions. Although the author has attempted to make the book up-to-date at the time of publication and to include pertinent recent references, anyone working in any branch of the electronics field will be aware of the difficulty faced by a single author in achieving this goal at the present time of very rapid growth.

H. J. R.

New Haven, Conn.
April 1, 1961

CONTENTS