A First Course in Applied Electronics

Other titles in Electrical and Electronic Engineering

J. C. Cluley: *Electronic Equipment Reliability*

B. A. Gregory: *An Introduction to Electrical Instrumentation*

Paul A. Lynn: *An Introduction to the Analysis and Processing of Signals*

A. G. Martin and F. W. Stephenson: *Linear Microelectronic Systems*

A. Potton: *An Introduction to Digital Logic*

J. T. Wallmark and L. G. Carlstedt: *Field-Effect Transistors in Integrated Circuits*

G. Williams: *An Introduction to Electrical Circuit Theory*

A First Course in Applied Electronics

An Introduction to Microelectronic Systems

W. Gosling

*Professor of Electronic Engineering
University of Bath*

M

© W. Gosling 1975

All rights reserved. No part of this publication
may be reproduced or transmitted, in any form
or by any means, without permission

First published 1975 by

THE MACMILLAN PRESS LTD

London and Basingstoke

Associated companies in New York Dublin

Melbourne Johannesburg and Madras

SBN 333 17174 8

ISBN 978-1-349-02362-2 ISBN 978-1-349-02360-8 (eBook)

DOI 10.1007/978-1-349-02360-8

The paperback edition of this book is sold subject to the condition that it shall
not, by way of trade or otherwise, be lent, re-sold, hired out, or otherwise
circulated without the publisher's prior consent in any form of binding or
cover other than that in which it is published and without a similar condition
including this condition being imposed on the subsequent purchaser.

Contents

<i>Preface</i>	ix
1 Introduction to Electronics	1
1.1 Systems and Parts	1
1.2 Integrated Circuits	2
1.3 Integrated Circuit Fabrication Technologies	3
1.4 Amplifiers—General	4
2 Fundamental Principles of Amplification	8
2.1 Introduction	8
2.2 Controlled Energy Conversion	8
2.3 Controlled Variable Dissipation Devices	9
2.4 Switching Amplifiers	13
2.5 Negative Resistance Amplifiers	15
2.6 Parametric Amplifiers	17
2.7 The Different Kinds of Amplifier Reviewed	18
3 More about Amplifiers	21
3.1 Equivalent Circuits	21
3.2 The Norton Form	25
3.3 Frequency Response	26
3.4 The Bel	28
3.5 Frequency-Response Plots	29
3.6 Other Causes of Falling High-Frequency Output	33
3.7 Low-Frequency Effects	35
3.8 Narrow-band Amplifiers	37
3.9 Signal-Handling Capacity	41

3.10	Working-Point and Biasing	42
3.11	Amplifier Terminology and Symbolic Diagrams	47
4	Unwanted Outputs	52
4.1	Introduction	52
4.2	Sources and Types of Noise	52
4.3	Specifying Amplifier Noise	55
4.4	Drift	57
5	Feedback	59
5.1	Introduction	59
5.2	Series Voltage Feedback	63
5.2.1	<i>Series voltage feedback with real loop gain</i>	66
5.2.2	<i>Series voltage feedback with complex loop gain</i>	70
5.3	Other Feedback Configurations	73
5.3.1	<i>Series current feedback</i>	73
5.3.2	<i>Shunt feedback</i>	76
5.4	Feedback: A Recapitulation	78
6	Feedback in Practice	82
6.1	Introduction	82
6.2	Trading Gain for Band-width	82
6.3	Oscillation and Trigger Circuits	86
6.4	Trigger Circuits in Practice	88
6.5	Sinusoidal Oscillators	91
6.6	Feedback and Unwanted Signals	92
6.7	Feedback and Distortion	93
6.8	Working-Point Stabilization	96
7	Feedback Problems	100
7.1	Negative into Positive Feedback	100
7.2	Unwanted Feedback	102
8	Integrated Amplifiers	106
8.1	The Economic Ground Rules	106
8.2	Bipolar Transistor Amplifiers	109
8.2.1	<i>Special circuit configurations</i>	112
8.3	A Simple Integrated Amplifier	118

8.4	The 741—A Sophisticated Operational Amplifier	121
8.4.1	<i>Characteristics of the 741</i>	125
8.5	Some Other Integrated Amplifiers	126
8.6	Packaging the Integrating Amplifier	129
9	Some Practical Examples	132
9.1	Introduction	132
9.2	The 741 as an Inverting Amplifier	134
9.3	The 741 as a Non-inverting Amplifier	135
9.4	Raising the Input Impedance	138
9.5	Raising the Available Output Power	140
9.6	Narrow-band Amplifier and Active Filters	144
9.7	A Monostable Multivibrator	146
9.8	A Sinusoidal Oscillator	148
	<i>Answers to question</i>	151
	<i>Index</i>	159

Preface

Some years ago the author prepared a book intended to be a first textbook on applied electronics for undergraduates. The project arose from a widespread feeling that, as a result of the introduction of microcircuits, a new approach was required to elementary electronics teaching.

Over the last quarter of a century the approach to teaching had settled down to a standardized form, based on electronic physics as its starting point. Thus quantum mechanical theory of solids played a central role and most electronics textbooks began with an elementary introduction to this subject. Thereafter it was normal to progress to a treatment of the physical properties of the electronic device, particularly bipolar transistors. Only at that point did it become possible to discuss the applications of devices in typical circuits such as are in everyday use.

Though this approach to teaching the subject was admirable in some ways, it suffered from the defect that it placed the emphasis primarily on the physics of electrical devices and only to a much lesser extent on their applications, yet it was the latter which formed the primary motivation of study in most cases.

With the introduction of microcircuits, the path from quantum physics to useful applications becomes very long indeed. Electronics specialists, and particularly those who hope to design integrated circuits themselves, will naturally have to pursue the subject back to its physical origins. There will be many, however, including the majority of professional engineers concerned with using electronics, to whom the physical processes occurring within the microcircuits will be a matter of much less importance. For them the fundamental starting point will be the terminal properties of the integrated circuit, and they will be concerned with its effective application in complicated electronic systems.

Thus it seemed right to try to design a course which regarded the properties of the microcircuit as the basic starting point. As far as digital circuits are concerned, it is the integrated logic blocks which are primitive and a number of excellent textbooks are now available for students which take this as their starting point. By contrast, for linear systems the fundamental building block is of course the amplifier. Thus amplifiers form the starting point for a microcircuit-oriented linear-electronics course.

The original book was well received, and was adopted as a teaching text in a number of institutions, but like all pioneer efforts it suffered from certain inadequacies, and in particular was rather oversimplified in some sections. The present volume is a result of a very thorough reconstruction of the original text, based upon the advice received from many teachers and students, and it is confidently believed that the defects unavoidable in a first attempt at a new approach to teaching have now been eliminated. The author owes a tremendous debt of gratitude to the very many colleagues all over the world who were so kind as to write to him welcoming the book, and giving constructive criticisms and suggestions for its revision. It is a pleasure to acknowledge the contribution made by many friends in universities and polytechnics, because without their help it is doubtful whether this experiment in electronics teaching could have gone any further. It is to be hoped that they will feel that their comments have resulted in the production of the book they were so obviously looking for.

In addition to providing a first-year course for electronics students (by whom it will be used in conjunction with elementary texts on circuit theory and physical electronics), it is believed that this book will be of value for non-electronics specialists, in physics, chemistry and the biological sciences, who require an operational knowledge of applied electronics as part of their professional equipment. Since the prerequisite of this book excludes physics and consists only of mathematics (up to elementary calculus) and a simple knowledge of electrical-circuit theory (up to complex-number representations), most such students will be able to use it effectively.

Finally I should like to express my thanks to Mrs Carolyn Scantlebury, who typed the manuscript.