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Electronic and Electrical Engineering

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Second Edition



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Preface

FOUR YEARS have passed since the first edition of this book appeared and of course matters have changed: new products have appeared, some of the old have disappeared; new techniques have emerged, and some of the old have become less important. Fortunately most of the principles are as sound and as relevant today as they were in the past, but some updating is inevitably required. In this new edition I have removed very little and included new material where necessary – solar cells are now used quite often by students for example – and consequently the text is a little bigger. I have rewritten some parts at the suggestion of colleagues and other users of the text, and the layout of the diagrams has been changed: for the better one hopes.

A working knowledge of the basic principles and many of the important practical applications of electronic and electrical engineering is essential to practitioners of many other disciplines. From teaching electrical engineering subjects to electrical, civil, mechanical and production engineering students over a number of years, I have been encouraged to produce a book which goes into sufficient depth to be useful, without being over-complicated or cluttered with too-rigorous and exhaustive a mathematical treatment. The level of mathematical difficulty is approximately that of A-level, though in the great majority of chapters less is demanded. The purpose has been to establish the foundations thoroughly and then build on them using modern applications wherever possible. Though the requirements of the non-specialist have been kept in mind throughout, the intention nevertheless has been also to provide a useful first-year course for specialists.

The book starts with two chapters on the fundamental subject of circuit analysis, followed by chapters on operational amplifiers and the steady-state and transient responses of circuits. Necessary semiconductor theory is reviewed in chapter six, after which discrete devices and circuits are discussed in chapters seven, eight and nine. Chapter ten deals with integrated circuit fabrication and chapter eleven with analogue circuits. Machines and power are discussed in the next series of chapters starting with chapter twelve, which includes a new section on batteries. Digital electronics, computers and microprocessors are discussed in chapters twenty to twenty-three. There are four chapters given to communications, including analogue, digital and fibre-optic communications and telephony. Two concluding chapters deal with less-central subjects which are nevertheless of considerable importance to a wide public: electromagnetic compatibility (EMC), and instruments and measurements. EMC requirements are subject to ever more wide-ranging EC laws affecting every single piece of electrical equipment made and used in the Community, and all engineers must have some knowledge of electrical measurements and their accuracy.

My thanks are due to my colleagues who have used this book in their programme modules, especially Dr V V Vadher, who made constructive comments on the machines and power chapters. Many students have kindly offered suggestions and pointed out errors and omissions: my thanks to all of them too.

Loughborough, 1998

L.A.A.W

Physical constants

The speed of light in a vacuum, c	3×10^8 m/s
The permeability of free space or the magnetic constant, μ_0	$4\pi \times 10^{-7}$ H/m
The permittivity of free space or the electric constant, ϵ_0	8.85×10^{-12} F/m
Planck's constant, h	6.626×10^{-34} Js
Boltzmann's constant, k	1.38×10^{-23} J/K
The magnitude of the electronic charge, q	1.6×10^{-19} C
The ice point	273.2 K

Notes: $c = 1/\sqrt{(\mu_0\epsilon_0)}$. Impedance of free space, $Z_0 = \sqrt{(\mu_0/\epsilon_0)} = 377 \Omega$. The above, where approximated, are accurate to $\pm 0.14\%$.

Unit prefixes

a	atto	10^{-18}
f	femto	10^{-15}
p	pico	10^{-12}
n	nano	10^{-9}
μ	micro	10^{-6}
m	milli	10^{-3}
k	kilo	10^3
M	mega	10^6
G	giga	10^9
T	tera	10^{12}
P	peta	10^{15}
E	exa	10^{18}

Notes: Order is important, so that 1 msV = 1 millisecond-volt while 1 Vms = 1 volt-metre-second; if in doubt, hyphenate. Lower and upper case styles for units and prefixes must be carefully followed: 1 Kgm = 1 Kelvin-gram-metre, while 1 kgm = 1 kilogram-meter and 1 kg = 1 kilogram; 1 mS = 1 millisiemens, 1 ms = 1 millisecond. Note also that $1 \text{ mm}^2 = 1 \text{ square mm}$. Submultiples in denominators should be removed to the numerator, so that 1 pF/mm² becomes 1 $\mu\text{F}/\text{m}^2$.

Units

Base units

quantity	unit	symbol	dimension
Mass	kilogram	kg	M
Length	metre	m	L
Time	second	s	T
Current	ampere	A	I
Temperature	kelvin	K	θ

Derived units

quantity	unit	symbol	dimensions
frequency	hertz	Hz	T^{-1}
speed	metre/second	m/s	LT^{-1}
acceleration	metre/sec/sec	m/s^2	LT^{-2}
force	newton	N	MLT^{-2}
work, energy	joule	J	ML^2T^{-2}
power	watt	W	ML^2T^{-3}
charge	coulomb	C	TI
potential	volt	V	$ML^2T^{-3}I^{-1}$
resistance	ohm	Ω	$ML^2T^{-3}I^{-2}$
conductance	siemens	S	$M^{-1}L^{-2}T^3I^2$
capacitance	farad	F	$M^{-1}L^{-2}T^4I^2$
inductance	henry	H	$ML^2T^{-2}I^{-2}$
magnetic field	ampere/metre	A/m	$L^{-1}I$
flux density	tesla	T	$MT^{-2}I^{-1}$
magnetic flux	weber	Wb	$ML^2T^{-2}I^{-1}$