C. R. Robertson

## Fundamental Electrical & Electronic Principles



## Contents

	Preface	xi
	Introduction	xii
1	Fundamentals Units Standard Form Notation 'Scientific' Notation Conversion of Areas and Volumes Graphs Basic Electrical Concepts Communication Assignment Questions Supplementary Worked Examples Summary of Equations	1 1 2 2 4 5 7 23 26 27 33
2	D.C. Circuits Resistors in Series Resistors in Parallel Potential Divider Current Divider Series/Parallel Combinations Kirchhoff's Current Law Kirchhoff's Voltage Law Other Network Theorems Superposition Theorem Constant Voltage and Constant Current Sources and their Equivalence Thévénin's Theorem Norton's Theorem The Maximum Power Transfer Theorem The Decibel and its Usage The Wheatstone Bridge Network The Wheatstone Bridge Instrument The Slidewire Potentiometer Assignment Questions	34 34 39 44 45 47 50 52 56 56 58 61 65 68 70 76 83 85 87

## vi Contents

	Suggested Practical Assignments	96
	Supplementary Worked Examples	99
	Summary of Equations	122
3	Electric Fields and Capacitors	123
	Coulomb's Law	123
	Electric Fields	124
	Electric Field Strength	126
	Electric Flux and Flux Density	126
	The Charging Process and Potential Gradient	127
	Capacitance	130
	Capacitors	130
	Permittivity of Free Space	131
	Relative Permittivity	131
	Absolute Permittivity	131
	Calculating Capacitor Values	132
	Capacitors in Parallel	134
	Capacitors in Series	136
	Series/Parallel Combinations	140
	Multiplate Capacitors	142
	Energy Stored	144
	Dielectric Strength and Working Voltage	147
	Capacitor Types	148
	Assignment Questions	151
	Suggested Practical Assignment	155
	Supplementary Worked Examples	155
	Summary of Equations	162
1	Magnetic Fields and Circuits	163
4	Magnetic Fields and Circuits  Magnetic Materials	163
	Magnetic Fields	163
	The Magnetic Circuit	166
	Magnetic Flux and Flux Density	167
	Magnetomotive Force	168
	Magnetic Field Strength	170
	Permeability of Free Space	171
	Relative Permeability	171
	Absolute Permeability	171
	Magnetisation (B/H) Curve	173
	Composite Series Magnetic Circuits	177
	Reluctance	180
	Comparison of Electrical, Magnetic and Electrostatic Quantities	184
	Magnetic Hysteresis	185
	Parallel Magnetic Circuits	187
	Assignment Questions	187
	Suggested Practical Assignments	189

		Contents	vii
	Supplementary Worked Examples		192
	Summary of Equations		196
	Entypo h		
5	Electromagnetism		197
	Faraday's Law of Electromagnetic Induction		197
	Lenz's Law		199
	Fleming's Righthand Rule		200
	EMF Induced in a Single Straight Conductor		203
	Force on a Current-Carrying Conductor		207
	The Motor Principle		209
	Force between Parallel Conductors		211
	The Moving Coil Meter		215
	Shunts and Multipliers		218
	Shunts		218
	Multipliers		219
	Figure of Merit and Loading Effect		221
	The Ohmmeter		223
	Wattmeter		224
	Eddy Currents		226
	Self and Mutual Inductance		227
	Self-Inductance		228
	Self-Inductance and Flux Linkages		230
	Factors Affecting Inductance		232
	Mutual Inductance		234 235
	Relationship between Self- and Mutual-Inductance		236
	Energy Stored The Transformer Principle		237
	Transformer Voltage and Current Ratios		239
	Assignment Questions		242
	Suggested Practical Assignments		246
	Supplementary Worked Examples		249
	Summary of Equations		257
4	Alternating Quantities		259
6	Alternating Quantities Production of an Alternating Waveform		259
	Angular Velocity and Frequency		262
	Standard Expression for an Alternative Quantity		262
	Average Value		265
	r.m.s. Value		266
	Peak Factor		266
	Form Factor		267
	Rectifiers		269
	Half-wave Rectifier		270
	Full-wave Bridge Rectifier		271
	Rectifier Moving Coil Meter		273
	Phase and Phase Angle		275

## viii Contents

Intrinsic (pure) Semiconductors

Electron-Hole Pair Generation and Recombination

	Phasor Representation Addition of Alternating Quantities The Cathode Ray Oscilloscope Operation of the Oscilloscope Dual Beam Oscilloscopes Assignment Questions Suggested Practical Assignments Supplementary Worked Examples Summary of Equations		277 279 284 286 288 289 292 292 296
7	Single Phase a.c. Circuits		
,	Pure Resistance		297
	Pure Inductance		297
	Inductive Reactance		299 301
	Pure Capacitance		304
	Capacitive Reactance		306
	Impedance		310
	Inductance and Resistance in Series		310
	Resistance and Capacitance in Series		316
	Resistance, Inductance and Capacitance in Series		319
	Power in the a.c. Circuit		323
	Power Factor		323
	Power Triangle Series Resonance		324
			326
	Assignment Questions Suggested Practical Assignments		330
	Supplementary Worked Examples		333
	Summary of Equations		336
	or Equations		344
8	Control Principles		345
	Introduction		345
	Non-engineering Applications		345
	Engineering Applications		346
	Classification of Control Systems Open-loop Systems		346
	Closed-loop Systems		347
	Transfer Functions and Block Diagrams		348
	A Positional Control System		351
	System Response and Stability		354
	Assignment Questions		355
	<u> </u>		357
9	Semiconductor Theory and Devices		358
	Atomic Structure		358

358

359

361

Contents	ix
OTTOTAL	1.0

Conduction in Intrinsic Semiconductors	362
Extrinsic (Impure) Semiconductors	363
n-type Semiconductor	363
p-type Semiconductor	364
The p-n Junction	366
The p-n Junction Diode	367
Forward-biased Diode	367
Reverse-biased Diode	368
Diode Characteristics	369
The Bipolar Junction Transistor (BJT)	370
Transistor Circuit Configurations	372
BIT Common Emitter Characteristics	373
BIT Common Base Characteristics	377
Relationship Between $h_{FE}$ and $h_{FB}$	381
The Unipolar Junction Transistor (UJT)	382
The JUGFET	382
n-channel JUGFET Characteristics	383
IUGFET Parameters	384
The Metal-Oxide Semiconductor Transistor (MOSFET)	387
Depletion Mode MOSFET	388
Comparison of FETs with BJTs	391
Assignment Questions	391
Suggested Practical Assignments	392
Summary of Equations	393
The second secon	
Semiconductor Circuits	394
The Zener Diode	394
Transistor Bias	398
A Simple Bias Circuit	399
Thermal Runaway	401
Bias with Thermal Stabilisation	402
Three-resistor Bias and Stabilisation	402
Biasing Circuits for FETs	404
Small-signal a.c. Amplifiers	405
Three-resistor-biased Amplifier Circuit	414
FET Small-signal Amplifier	417
The Transistor as a Switch	421
Assignment Questions	423
Suggested Practical Assignments	427
Supplementary Worked Examples	430
Summary of Equations	434
,	
Answers to Assignment Questions	435
Appendix A: SI Units and Quantities	441
Index	443