

A Simplified Approach to

Basic Electronics

SANGUINE

Dr. UB Mahadevaswamy

*A Simplified Approach
to*
Basic Electronics

Basic Electronics

Dr. U. B. Mahadevaswamy

Professor,

Department of Electronics and Communication,
Sri Jayachamarajendra College of Engineering,
Mysore 570 006, India



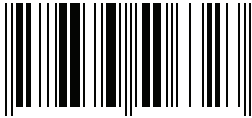
Sanguine Technical Publishers

Bangalore - 560016

2015

Price: ₹.335.00
\$.9.99

ISBN 978 9383506 32 3



9 789383 506323 >

Title: Basic Electronics
Dr.U. B. Mahadevaswamy

This book contains information obtained from authentic and highly regarded sources. Reprinted material is quoted with permission, and sources are indicated. Reasonable efforts have been made to publish reliable data and information, but the author and the publisher cannot assume responsibility for the validity of all materials or for the consequences of their use.

Neither this book nor any part of it may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, microfilming and recording, or by any information storage or retrieval system, without prior permission in writing from the publishers.

The consent of *SANGUINE TECHNICAL PUBLISHERS* does not extend to copying for general distribution, for promotion, for creating new works, or for resale. Specific permission must be obtained in writing from SANGUINE for such copying.

The export rights of this book are vested solely with the publisher.

Direct inquiries: *E-mail:* info@sanguineindia.com

Postal Address: #60, 2nd Main Road, Krishnappa Layout, RMV 2nd Stage,
Sanjaynagar, Bangalore – 560 016, India.

Visit our website at www.sanguineindia.com

© 2015 by Sanguine Technical Publishers, Bangalore – 560 016.

Published by *Lal Prasad* for *SANGUINE*

Production Editor: *R.Subramanian*

Typeset in *Times New Roman* by *Sriranga Graphics*.

Printed at : *Lakshmi Mudranalaya*.

*Submitted at the Lotus Feet of
His Holiness
Parama Poojya Lingaikya Jagadguru
Shree Shree Shree Shivaratri Rajendra Mahaswamigalavaru,
Founder President
J. S. S. Mahavidyapeeta
Mysore.*

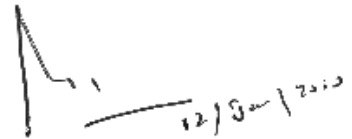
*In Fond Memory of My Grand Mother
Late Smt. M. S. Basamma
and
My Father
Late Shree T. N. Basavaraju
who are responsible for what I am today.*

FOREWORD

It gives me immense pleasure to present before you this book on **BASIC ELECTRONICS** authored by my colleague Dr. U.B. Mahadevaswamy. The book has been carefully drafted with enormous number of practical examples to support the theoretical concepts explained in this book. Difficult concepts are explained in simple and easily understandable terms backed by ample illustrations.

This book is a result of over 25 years of teaching experience of the author at various levels. I am sure that the readers will find the book extremely useful from both theoretical and practical point of view.

I wish the author success and sincerely hope that more publications would emerge out of his vast experience of teaching and research in electronics.

A handwritten signature in black ink, appearing to read 'Dr. Syed Shakeeb ur Rehman', with a date '12/3/2013' written below it.

(Dr. Syed Shakeeb ur Rehman)

Principal

PREFACE

This text book entitled Basic Electronics is written for beginners with a thirst of understanding the fundamentals of Electronics. This book is written in a simple and reader friendly manner so that the reader feels as if he is reading a novel. The concepts presented are in a simple and lucid manner. The book is packed with plenty of numerical examples which covers both analysis and design aspects.

This book covers topics in Basic Electronics such as Semiconductor Diodes and their Applications, Transistor Basics and Biasing, Op-Amp and its Applications. It also covers the fundamentals of Digital Electronics, basics of Microprocessors and Micro controllers. The operating principle of various types of Transducers and their applications has also been discussed. Finally it also discusses the basics of Communication and different types of Advanced Communication Systems.

I hope that this book will definitely serve as an excellent reference material for beginners and teachers. In spite of several readings by reviewers, few mistakes might have crept in. I open heartedly welcome the suggestions from the readers, teachers to make this book to come in a better form. You may send your comments to *info@sanguineindia.com*.

U. B. MAHADEVASWAMY

ACKNOWLEDGMENTS

Firstly, I submit my reverential pranams at the lotus feet of His Holiness parama poojya Jagadguru Shree Shree Shree Shivarathri Deshikendra Mahaswamigalavaru, President, JSS Mahavidyapeetha, Mysore. His divine blessing has always been a continuous source of inspiration in all my endeavors.

I greatly acknowledge all the encouragement and support rendered by Dr. Syed Shakeeb Ur Rehman, principal, SJCE Mysore, in drafting this book.

I deeply remember Late Dr. R.D Sudhaker Samuel, my teacher, my former H.O.D, who taught me the art of book writing.

I must acknowledge the support and encouragement rendered by Dr. M.N. Shanmukhaswamy, Head of EC department, SJCE Mysore.

My heartfelt thanks to my friend, colleague Prof. V. Nattarasu for his continuous support and guidance in making this book.

I must acknowledge the support and encouraging words rendered by my teacher, colleague and my well-wisher Dr. Chamaraju, Professor Department of Mathematics, SJCE, Mysore, in making this book.

I also thank my Colleague Dr. Shankaraiah, Professor, EC Department, SJCE, Mysore for his support in making this book.

I thank Mr. R Subramanian of Sanguine Technical Publishers for his meticulous review of this book and valuable suggestions for improving the quality of this book.

My special thanks to Smt. Rashmi S., Assistant professor, EEE department, VVCE Mysore for her sincere effort in reviewing the content of this book several times and her valuable suggestions for improving the quality of this book both in technical as well as conceptual presentation aspects. Her husband Mr. G.V. Krishna also needs a special mention for his encouraging words while drafting this book.

I must acknowledge all the encouragement and support from my wife Smt. K.S. Umadevi and my son Master Jeevan M. Swamy in making this project a success. I appreciate their patience and tolerance in sparing me for not accessible to them for long hours during most of the days while drafting this book. The encouraging words of my brother Mr. B. Chandra ShekaraMurthy, Quality control Engineer, Muscat, over phone is unforgettable.

I cherish in my heart, the heartfelt blessings of my mother Smt. K.P. Leelavathy at each and

every stage of drafting this book. The support rendered by all my family members need a special mention.

Finally I express my sincere gratitude for Sanguine Publishers for their constant support to convert my dreams into reality.

U. B. MAHADEVASWAMY

Contents

1	<i>p-n</i> Junction Diode	1
1.1	<i>p-n</i> junction	1
1.2	Conditions under which a <i>p-n</i> junction diode can be destroyed	2
1.3	Classification of diodes based on currents	2
1.4	Description and ratings of a low-current diode	3
1.5	Description and ratings of a medium-current diode	3
1.6	Description and ratings of high-current diode	3
1.7	Forward and reverse characteristics of a Silicon diode	4
1.8	Forward and reverse characteristic of a Germanium diode	8
1.9	Comparison between Silicon and Germanium diodes	12
1.10	Important diode parameters	12
1.11	Dynamic resistance of diode and its graphical determination	13
1.12	Characteristics of an ideal diode	16
1.13	Kirchhoff's Voltage Law	18
1.14	Piecewise-linear characteristics of diode	22
1.15	<i>dc</i> equivalent circuit of diode	24
1.16	DC load line	27
1.17	Need for graphical analysis or DC load line	28
1.18	Meaning of Q-point	29
1.19	Capacitive effects in <i>p-n</i> junction	31
	1.19.1 Depletion layer capacitance	31
	1.19.2 Diffusion capacitance	32
1.20	<i>ac</i> equivalent circuit of a diode, under reverse and forward biased conditions . .	33
1.21	Reverse-recovery time in a diode	34
1.22	Junction Breakdown in diodes	35
	1.22.1 Avalanche Breakdown	36
	1.22.2 Zener Breakdown	36

1.23	Zener Diode and Its V - I Characteristics	37
1.24	Zener diode parameters	38
1.25	Equivalent Circuit of Zener Diode	40
1.26	Applications of Zener Diode	41
2	Semiconductor Diode Applications	45
2.1	Need for rectification	45
2.1.1	Rectifier	45
2.2	Half-wave rectifier	46
2.3	Expressions for (a) Average/DC load current and load voltage (b) RMS load current and load voltage	47
2.4	Percentage regulation	52
2.4.1	Expression for percentage regulation of half wave rectifier	52
2.5	Rectification efficiency	53
2.5.1	Expression for rectification efficiency of half wave rectifier	53
2.6	Ripple factor	56
2.6.1	Ripple factor of half wave rectifier	56
2.7	Peak inverse voltage	57
2.7.1	Peak inverse voltage of half wave rectifier	57
2.8	Summary of results for half-wave rectifier	58
2.9	Full-wave rectifier using two diodes and a centre-tapped transformer	62
2.10	Expressions for (a) DC load current and load voltage (b) RMS load current and load voltage of full wave rectifier	64
2.11	Expression for percentage regulation of full-wave rectifier	67
2.12	Expression for efficiency of rectification of full-wave rectifier	68
2.13	Ripple factor of full-wave rectifier	70
2.14	Peak inverse voltage in full-wave rectifier	71
2.15	Summary of results for Full-wave rectifier using two diodes	72
2.16	Full-wave bridge rectifier	81
2.17	Peak inverse voltage for full-wave bridge rectifier	85
2.17.1	Comparative study of rectifier circuits	89
2.18	Filters for rectifier circuits	90
2.19	Half-wave rectifier with capacitor filter	90
2.20	Expressions for ripple factor and dc output voltage in half wave rectifier with capacitor filter	91
2.21	Full-wave rectifier with capacitor filter	95
2.22	Full-wave bridge rectifier with capacitor filter	97
2.23	Expressions for ripple factor and dc output voltage, in a full wave rectifier with capacitor filter	98
2.24	Expression for diode current for a full-wave rectifier circuit with capacitor filter	101

2.25	dc Power Supply	109
2.26	Line Regulation and Load Regulation as Applied to <i>dc</i> Power Supplies	110
2.27	Voltage Regulator	112
2.28	Zener Diode Voltage Regulator	113
	2.28.1 Zener diode voltage regulator under no load	113
	2.28.2 Loaded Zener diode voltage regulator	117
2.29	Clipping Circuits	131
2.30	Series Clipper	131
	2.30.1 Negative series clipper	131
	2.30.2 Positive clipper	133
	2.30.3 Series noise clipper	137
2.31	Shunt Clipping Circuits	138
	2.31.1 Positive shunt clipper	138
	2.31.2 Design equations of positive shunt clipper	140
	2.31.3 Negative shunt clipper	141
	2.31.4 Design equations of negative shunt clipper	143
	2.31.5 Shunt noise clipper	148
	2.31.6 Application of shunt clipper	148
2.32	Biased shunt clipper	148
2.33	Zener Diode Shunt Clipper	151
2.34	Clamping Circuits	154
	2.34.1 Negative voltage clamping circuit	156
	2.34.2 Positive voltage clamping circuit	157
	2.34.3 Output slope	158
	2.34.4 Component selection	159
3	Bipolar Junction Transistor	167
3.1	Transistor construction	167
3.2	Barrier voltages in unbiased <i>npn</i> transistor	168
3.3	Operation of <i>npn</i> transistor	169
3.4	Operation of <i>pnp</i> transistor	170
3.5	Directions of I_E , I_C and I_B in <i>npn</i> and <i>pnp</i> transistors	172
3.6	Terminal voltages in an <i>npn</i> transistor	173
3.7	Terminal voltages in a <i>pnp</i> transistor	174
3.8	Transistor current gains	175
	3.8.1 Emitter to collector current gain	175
	3.8.2 Base to collector current gain	176
3.9	Reverse saturation current, I_{CB0}	176
3.10	To express I_C in terms of I_B and α_{dc}	177
3.11	Relation between α_{dc} and β_{dc}	177

3.12	β_{dc} in terms of α_{dc}	178
3.13	Transistor configurations	185
3.13.1	Common-emitter configuration	185
3.13.2	Common-base configuration	186
3.13.3	Common-collector configuration	186
3.14	BJT current amplification	187
3.14.1	Common-emitter ac current gain (β_{ac})	187
3.15	Voltage amplification in BJT	188
3.16	Transistor characteristics	196
3.17	Common-Base input characteristics	196
3.18	Common-Base output characteristics	198
3.18.1	Suitability of operating regions for the intended application of transistor	199
3.18.2	Breakdown in transistor	199
3.19	Current gain characteristics of common-base configuration	200
3.20	Common-Emitter input characteristics	203
3.21	Common-Emitter output characteristics	204
3.22	Current gain characteristics of Common-Emitter configuration	206
3.23	Common-Collector input characteristics	207
3.24	Common-Collector output characteristics	208
3.25	Common-Collector current gain characteristics	209
3.26	Performance comparison of transistor configurations	210
4	Transistor Biasing	213
4.1	Need for biasing	213
4.1.1	DC load line	213
4.1.2	Procedure for drawing the DC load line on the transistor CE output characteristics	214
4.2	DC Bias point or Q point	218
4.2.1	Variation of I_B , I_C and V_{CE} with the application of input signal	218
4.2.2	Selection of Q -point	221
4.3	Biasing circuits	224
4.3.1	Requirements of a Biasing circuit	224
4.4	Base bias or Fixed current Bias	224
4.5	Design of Base-bias circuit	238
4.6	Voltage divider bias circuit	241
4.7	Analysis of voltage divider bias circuit	242
4.7.1	Approximate analysis of voltage divider bias circuit	242
4.8	Accurate analysis of voltage divider bias circuit	244
4.9	Design of voltage divider bias circuit	252
4.10	Thermal stability of bias circuits	258

4.11	Thermal stability of Q point in Base-Bias	258
4.12	Thermal stability of Q point in voltage divider bias circuit	259
5	Operational Amplifier	261
5.1	Operational Amplifier	261
5.1.1	Circuit symbol of Op-amp	262
5.1.2	Operation of an Op-amp	263
5.1.3	Properties of an ideal Op-amp	264
5.1.4	Properties of a practical Op-amp	264
5.2	Block diagram of a typical OP-amp	265
5.2.1	Integrated circuit Op-amp ($\mu A741$)	265
5.2.2	Typical values of various Op-amp parameters for $\mu A741$ IC	266
5.2.3	Equivalent circuit of an Op-amp	267
5.3	Necessity of negative feedback in an Op-amp amplifier	267
5.4	Typical frequency response of an Op-amp and the effect of negative feedback on bandwidth of the Op-amp	268
5.5	Slew-rate of an Op-amp and its significance	270
5.6	Common-mode rejection ratio or CMRR of an Op-amp and its significance	273
5.7	Concept of virtual short in an Op-amp	276
5.8	Basic Op-amp circuits	277
5.9	Op-amp inverting amplifier	277
5.10	Op-amp non-inverting amplifier	286
5.11	Expression for input resistance of Op-amp inverting amplifier	291
5.12	Linear Applications of Op-amp	294
5.13	Voltage follower	294
5.14	Important properties of Op-amp voltage follower	295
5.15	Op-amp summer or summing amplifier	296
5.16	Op-amp subtractor	302
5.17	Alternate circuit for subtractor	304
5.18	Op-amp as an integrator	307
5.19	Op-amp as differentiator	308
6	Digital Electronic Circuits	323
6.1	Computer	323
6.1.1	Analog Computer	323
6.1.2	Digital Computer	324
6.2	Decimal number system	324
6.3	Binary number system	326
6.4	Decimal to binary conversion	328
6.5	Octal number system with an example	331

6.6	Table of octal-binary equivalents	333
6.7	Hexadecimal number system	335
6.8	Binary addition	340
6.9	Addition of octal numbers	341
6.10	Addition of hexadecimal numbers	344
6.11	Binary subtraction	347
6.12	Binary coded decimal numbers	366
6.13	Boolean Algebra	368
6.14	Logic Gates	368
6.15	The logical AND operation	369
6.16	Construction of AND gate using diodes	370
6.17	The logical OR operation	373
6.18	Construction of OR gate using diodes	374
6.19	The logical NOT operation	376
6.20	Construction of NOT gate	376
6.21	Symbols, logic and truth-tables of the basic gates	378
6.22	The NAND operation	379
6.23	The NOR operation	379
6.24	Exclusive-OR (EX-OR) gate	380
	6.24.1 Implementation of EX-OR gate using Basic gates	381
6.25	Exclusive-NOR (EX-NOR) gate	381
	6.25.1 Implementation of EX-NOR gate using Basic gates	382
6.26	Basic Boolean Laws	382
6.27	De Morgan's Theorems	387
6.28	Universal gates	388
6.29	Half-adder	411
6.30	Full-adder	412
6.31	Implementation of full-adder using half-adders	415
6.32	Parallel Binary Adder	416
6.33	Characteristics of Logic gates	418
6.34	Classification of Digital Circuits	419
6.35	Latch	420
6.36	Flip-Flop	421
	6.36.1 R-S Flip-Flop using NAND gates (NAND gate latch)	422
	6.36.2 RS Flip-flop using NOR gates (NOR gate Latch)	425
6.37	Clock wave form	427
6.38	Clocked RS Flip-Flop	427
	6.38.1 Clocked RS Flip-Flop using NOR gates	427
	6.38.2 Clocked RS Flip-Flop using NAND gates	429

7	Microprocessors and Micro Controllers	431
7.1	Microprocessor	431
7.1.1	Word length of a microprocessor	432
7.1.2	Grouping of bits	433
7.2	Scale of Integration	433
7.3	Microprocessor - Based System	433
7.4	Microprocessor	434
7.4.1	Arithmetic/Logic Unit (ALU)	434
7.4.2	Register Array	434
7.4.3	Control Unit	434
7.4.4	Memory	435
7.4.5	I/O (Input/Output)	435
7.4.6	System Bus	435
7.5	Working of Microprocessor	435
7.6	Computer Languages	436
7.7	Combinations with n -bit binary word	437
7.8	The 8085 Microprocessor	437
7.8.1	Features of 8085 microprocessor	439
7.9	Architecture of 8085 microprocessor	440
7.10	Applications of Microprocessor	444
7.11	Micro Controller	445
7.12	The 8051 Micro Controller	446
7.13	The Salient Features of 8051 are as follows	447
7.14	Architecture of 8051	447
7.15	Applications of Micro Controllers	453
7.16	Differences between Microprocessor and Micro Controller	454
8	Transducers	455
8.1	Need for Transducers	455
8.2	Transducer	456
8.2.1	Difference between the sensor and the transducer	456
8.3	Classification of Transducers	456
8.4	Desirable properties of a Good Transducer	457
8.5	Mechanical Transducers	458
8.6	Strain Gage	460
8.6.1	Applications of strain gage	461
8.7	Passive electrical transducers	461
8.8	Resistive Transducers	462
8.8.1	Resistance Thermometer	462
8.8.2	Advantages of resistance thermometer	464

8.8.3	Disadvantages of resistance thermometer	464
8.9	Thermistor	464
8.9.1	Construction of thermistors	465
8.9.2	Applications of Thermistors	466
8.9.3	Advantages of thermistor	466
8.9.4	Disadvantages of thermistor	466
8.10	Resistive displacement transducers	466
8.11	Inductive transducers	468
8.11.1	The Linear Variable Differential Transformer (LVDT)	468
8.11.2	Applications of LVDT	471
8.12	Active Electrical Transducers	471
8.13	Thermoelectric Transducers	471
8.13.1	Seebeck Effect	472
8.13.2	Peltier Effect	473
8.13.3	Thomson Effect	474
8.13.4	Applications of Thermocouple	474
8.14	Piezo-Electric Transducer	474
8.14.1	Advantages of Piezo-electric Transducers	476
8.14.2	Applications of Piezo-electric Transducers	477
8.15	Photo Electric Transducers	477
8.15.1	Applications of Photo-Electric Transducers	478
9	Communication Systems : Part - I	479
9.1	Communication	479
9.2	Elements of communication systems	479
9.3	Modulation	480
9.4	Classification of communication systems based on the modulation scheme and input signal	481
9.5	Need for modulation in communication systems	481
9.6	Frequency ranges and their application	482
9.7	Amplitude modulation	483
9.8	Modulation index of amplitude modulation	485
9.9	Expression for the instantaneous voltage of amplitude modulated wave : AM wave equation	485
9.10	Expression for modulation index of amplitude modulation	486
9.10.1	Effect of modulation index on amplitude modulation	487
9.10.2	Significance of modulation index	487
9.10.3	Frequency spectrum of AM wave and its bandwidth	487
9.11	Expression for the total average power of a sinusoidal AM wave	490
9.12	Maximum power in an AM wave	492

9.13	Transmission efficiency of AM wave	492
9.14	Modulation index in terms of carrier power and total power of the AM wave	493
9.15	Modulation index and total power when a carrier is amplitude modulated by several sine waves	494
9.16	AM Detection (Demodulation of AM signal)	499
9.17	Angle modulation	501
9.17.1	Two methods of angle modulation	502
9.17.2	How PM and FM differ from AM?	502
9.18	Frequency modulation	503
9.18.1	Waveforms of frequency modulation	503
9.18.2	Frequency deviation in frequency modulation	503
9.18.3	Expression for the maximum frequency deviation of an FM wave	504
9.18.4	Expression for the FM wave	505
9.18.5	Modulation index for FM	506
9.18.6	Frequency spectrum and bandwidth of an FM wave	507
9.19	FM Detection	507
9.20	Limitations of amplitude modulation	510
9.21	Advantages of frequency modulation over amplitude modulation	511
9.22	Disadvantages of FM	511
9.23	Comparison between AM and FM	512
10	Communication Systems - Part II	515
10.1	Basic terminologies and their definitions	515
10.1.1	Data transmission modes in communication circuits	515
10.1.2	Telephone system	516
10.2	The telephone systems	517
10.2.1	Introduction	517
10.2.2	Working of telephone system	517
10.2.3	Telephone set (Telephone instrument)	518
10.3	Mobile Telephone (Cellular Telephone)	520
10.3.1	Mobile telephone unit (Cellular Telephone Unit)	522
10.4	Integrated Services Digital Network (ISDN)	523
10.5	Optical Fibre Communication System	524
10.5.1	Block diagram of an optical fibre communication system	525
10.5.2	Advantages of optical fibre cables	527
10.5.3	Applications of optical fibre communication	528
	Index	530

Chapter 1

p-n Junction Diode

The term diode denotes a two electrode device. **Di** means **two** and **ode** means electrode. A semiconductor diode is a two layer single junction two terminal unidirectional device. The current in a diode is contributed by both holes and electrons. Diode is the simplest of all semiconductor devices but plays a very important role in electronic systems. Diodes are used in variety of applications including communication systems, radio, TV, computers, power supplies and so on. This chapter begins with an explanation of the *p-n* junction diode and proceeds with its characteristics and parameters. Diode approximations, dc and ac equivalent circuits, temperature effects are presented with numerous examples. Zener diode and its characteristic have also been discussed at the end of this chapter.

1.1 *p-n* junction

A *p-n* junction diode is a two terminal unidirectional device with a *p*-type anode and an *n*-type cathode as shown in Fig. 1.1. It is said to be forward biased when its anode is kept at a positive potential with respect to its cathode. Under this condition, it offers a low resistance to the flow of current and acts as the closed condition of a switch. The current flowing in this condition is called forward current, I_F .

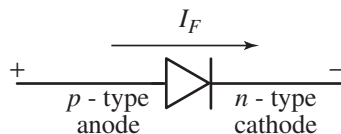


Fig. 1.1: Forward biased *p-n* junction diode

Basic Electronics



Publisher : [Sanguine Publishers](#) ISBN : 9789383506323

Author : [Dr. U. B. Mahadevaswamy](#)

Type the URL : <http://www.kopykitab.com/product/5994>



Get this eBook