

Fundamentals of Electrical Engineering

Authors

Dr. T. Rajesh

Professor, Department of EEE
Malla Reddy Engineering College
Campus 1, Maisammaguda
Secunderabad - 500 100 TS

Dr. A. V. Sudhakara Reddy

Associate Professor, Department of EEE
Malla Reddy Engineering College
Campus 1, Maisammaguda
Secunderabad - 500 100 TS

Ms. Y. Sudha Reddy

Assistant Professor, Department of EEE
Malla Reddy Engineering College
Campus 1, Maisammaguda
Secunderabad - 500 100 TS



All rights reserved. No part of this publication which is material protected by this copyright notice may be reproduced or transmitted or utilized or stored in any form or by any means now known or hereinafter invented, electronic, digital or mechanical, including photocopying, scanning, recording or by any information storage or retrieval system, without prior written permission from the **Publisher**.

Information contained in this book has been published by **StudentsHelpline Publishing House (P) Ltd. , Hyderabad** and has been obtained by its Authors from sources believed to be reliable and are correct to the best of their knowledge. However, the Publisher and its Authors shall in no event be liable for any errors, omissions or damages arising out of use of this information and specifically disclaim any implied warranties or merchantability or fitness for any particular use.

M/s Spectrum University Press, Hyderabad

A Part of StudentsHelpline Publishing House (P) Ltd. , Hyderabad

(An ISO 9001 : 2015 Certified Company)

Head Office

326/C, 1st Floor, Surneni Nilayam
Near B K Guda Park, S R Nagar, Hyderabad - 500 038, INDIA
P.No:+91 40 23710657, 238000657 Fax: +91 40 23810657

Reg. Off

5-68, Pedda Gorpada, Pakala, Tirupati, Chittoor - 517 112 AP, INDIA
mail:studentshelpline.in@gmail.com
www:studentshelpline.in

© Spectrum University Press

Second Edition-2019

ISBN 978-93-83640-48-5

244/-

Printed at M/s StudentsHelpline Group, S R Nagar, Hyderabad-38

Published by Surneni Mohan Naidu for Spectrum University Press, Hyderabad - 38

Fundamentals of Electrical Engineering

Unit-I: Fundamentals of Electricity

Introduction to circuit elements (R, L & C)- Electric Current - Electric Potential difference -Ohm's law - Factors upon which Resistance depends- Specific Resistance - Effect of Temperature on Resistance - Temperature coefficient of Resistance - Series and Parallel connection of Resistances, Inductances & Capacitances - Kirchhoff's laws (KCL & KVL)- Basic types of Sources (Independent Sources).

Unit-II: Protective Devices

Types of Fuses, Characteristics, Materials Used, Fuse Rating - Types of Switches, Materials used, Symbols - Types of Circuit breakers - Types of Resistors, Rating - Colour Coding of R, L, C.

Unit-III: Earthing

Need and Necessity of Earthing - Types of Earthing - Simple Earthing Circuits for domestic appliances - Procedure of Earthing - Earthing of Generators - Calculation of Earth resistance - Perfect earthing - Importance of neutral and its grounding.

Electrical Safety

Electrical Shock - Types of First aids - Safety Norms - Human Body response for various Electric Voltages.

Unit-IV: Measuring Instruments

Types of Measuring Instruments - Principle of operation - Measurement of Current, Voltage, Power Energy, Resistance, Inductance & Capacitance - Earth Resistance - Principle of Operation of CRO.

Fundamentals of Electrical Engineering

Unit-I: Fundamentals of Electricity

1.0	objectives	2
1.1	Introduction	2
1.2	Introduction to Circuit Elements (R-L-C Parameters)	3
1.3	Electric Current and charge	3
1.4	Voltage and E.M.F	6
1.5	Electric Potential	6
1.6	Potential Difference	7
1.7	Power and Energy	8
1.8	Ohm's Law at Constant Temperature	8
	1.8.1 Limitations of Ohm's Law	11
	1.8.2 Applications of Ohm's Law	11
	1.8.3 Solved Problems	11
	1.8.4 Nodes, Branches and Loops	15
1.9	Kirochhoff's Laws	17
	1.9.1 Solved Problems	21
1.10	Resistance (R)	28
	1.10.1 Factors Affecting the Resistance of a Material	29
	1.10.2 Specific Resistance	30
	1.10.3 Classification of Resistors	30

1.10.4	Colour Coding of Resistors	31
1.11	Effect of Temperature on Resistance	32
1.12	Temperature Co-efficient of Resistance	33
1.12.1	Expression for Resistance at any Temperature as $R_t = R_0(1 + \mu_0 t)$	35
1.12.2	Formula for Co-efficient of Resistance at any Temperature as $m_t = m_0(1 + m_0 t)$	36
1.12.3	Solved Problems	38
1.13	Conductivity	46
1.14	Series Resistance	47
1.14.1	Equivalent Resistance for Series Connections	48
1.14.2	Voltage Divider Rule	50
1.14.3	Solved Problems	52
1.15	Resistance in Parallel	55
1.15.1	Characteristics of a Parallel Circuits	57
1.16	Series-Parallel Combination	58
1.17	Division of Current in Parallel Branch Circuit	59
1.17.1	Solved Problems	62
1.17.2	Comparison of Series and Parallel Circuits	65
1.18	Solved Problems on Series and Parallel Circuit	66
1.19	Inductor (L)	78
1.19.1	Classification of Inductors	80
1.19.2	Specifications of Inductor	80
1.19.3	Series and Parallel Inductors	81

1.20	Capacitor	83
1.20.1	Classifications of Capacitors	86
1.20.2	Specifications of the Capacitor	86
1.20.3	Series and Parallel Capacitors	86
1.20.4	Comparison of Active and Passive Components	88
1.20.5	Important Characteristics of the Basic Elements	88
1.20.6	Solved Problems	89
1.21	Standard Symbols for Electrical Components	91
1.22	Voltage and Current Sources	94
1.23	Independent and Dependent Sources	95
1.23.1	Solved Problems	97
1.24	Outcomes	99
1.25	Summary	99
1.26	Review Questions	101
1.27	Multiple Choice Questions	107
Chapter-2: Protective Devices		
2.0	Objectives	112
2.1	Introduction	112
2.2	Fuse	112
2.2.1	Need	113
2.2.2	Characteristics of Fuse	114
2.3	Materials used for Fuse	115
2.4	Fuse Ratings	115
2.4.1	Significance of Fuse Ratings	117

2.5	Classification of Fuses	118
2.6	Requirements of a Fuse	122
2.7	Fusing Materials	123
2.8	Advantages and Disadvantages of Fuses	123
2.9	Switches	125
2.10	Classification of Switches	126
2.11	Switches-Ratings and Applications, I.S.I Symbols	129
2.12	Circuit Breakers	134
2.13	Functions of Circuit Breaker	135
2.13	Arc Phenomenon	135
	2.13.1 Principles of Arc Extinction	136
2.14	Classification of Circuit Breakers	138
	2.14.1 Types of Oil Circuit Breakers	138
	2.14.2 Low Oil C.B's	143
	2.14.3 Air Blast Circuit Breakers	143
	2.14.4 SF ₆ Circuit Breaker	146
	2.14.5 Vacuum Circuit Breakers	149
	2.14.7 Differentiate between a Fuse and a Circuit Breaker	151
	2.14.8 Factors which Influence the Performance of an Air Blast Circuit Breaker	151
	2.14.8 Dielectric Strength in SF ₆	152
	2.14.9 Characteristic of SF ₆ Gas	152
2.15	Resistor	153
	2.15.1 Specifications of Resistors	153
	2.15.2 Preferred Values	154

2.16	Types of Resistors	155
	2.16.1 Linear Resistors	156
	2.16.2 Non-linear Resistor	161
2.17	Common Faults in Resistors	162
2.18	Types of Inductors	163
	2.18.1 Important Parameters of Air Cored Inductors	164
	2.18.2 Common Faults in Inductors	164
2.19	Types of Capacitors	164
	2.19.1 Characteristics of Capacitors	165
	2.19.2 Specifications of Capacitors	166
	2.19.3 Markings on Capacitors	166
2.20	Colour Coding of RLC	172
	2.20.1 Resistor Colour Coding	172
	2.20.2 Colour Coding of Inductor	173
	2.20.3 Colour Coding of Capacitor	175
	2.20.4 Solved Problems	177
2.21	Outcomes	180
2.22	Summary	180
2.23	Review Questions	181
2.24	Multiple Choice Questions	183
Chapter-3: Earthing		
3.0	Objectives	188
3.1	Introduction	188

3.2	Earthing	188
3.3	Need and Necessity of Earthing	189
3.4	Advantages of Earthing	190
3.5	Specifications for Earthing as per I.S.I	190
3.6	Methods of Earthing	191
3.7	Components of Earthing System	191
3.8	Types of Earthing Systems	192
3.9	Types of Earthing	193
3.10	Selection of Earthing	197
3.11	Domestic Wiring and Circuits	197
3.12	Basic Home Wiring Circuits-Simplified Wiring Layout	198
3.13	Procedure of Grounding	199
3.14	Grounding of Generator	199
3.15	Protection of Overhead Transmission Lines	200
3.16	Coupling Factor	200
3.17	Grounding transformer	202
3.18	Steps for Earthing in Proper Installation	204
3.19	Important Terms Related to Earth Pit	204
3.20	Methods of Generator Neutral Grounding	205
3.21	Disadvantages of Ungrounded System	206
3.22	Advantages of Neutral Grounding	206
3.23	Ungrounded Neutral System	207
3.23	Earth Resistance	211

3.23.1	Factors Effecting the Earth Resistance	211
3.23.2	Methods of Reducing Earth Resistance	212
3.23.3	Purpose of Earthing	212
3.24	Measurement of Earth Resistance	212
3.25	Methods of Neutral Grounding	214
3.25.1	Solved Problems	220
3.26	Definition of Grounding	224
3.27	Definition of Earthing	225
3.28	Specifications for Earth Electrodes	226
3.29	Key Differences between Grounding and Earthing	226
3.20	Outcomes	228
3.21	Summary	228
3.22	Review Questions	228
3.23	Multiple Choice Questions	229
Chapter-4: Electrical Safety		
4.0	Objectives	234
4.1	Introduction	234
4.2	Electrical Shock	234
4.2.1	Causes	235
4.2.2	Different Ways to Experience Electrical Shock	235
4.2.3	Effects of Shock on the Human Body	236
4.2.4	Effects of Electric Shock and Electrocution	236
4.2.5	Electrical Injury	237

4.3	Types of Electric Shocks	238
4.4	Types of First Aids	239
4.5	Safety Norms	242
4.6	Signs & Symptoms of Electric Shock	242
4.7	Human body Responses for Various Electric Voltages	243
4.8	Treatment of Electric Shock	245
4.9	Troubleshooting-Electrical Safety	246
4.10	General Electrical Safety Rules	246
	4.10.1 Different Types of Safety Symbols	247
4.10	Outcomes	248
4.11	Summary	248
4.12	Review Questions	249
4.13	Multiple Choice Questions	249
Chapter-5: Measuring Instruments		
5.0	Objectives	252
5.1	Introduction	252
5.2	Measurement and Instrument	252
	5.2.1 Necessary Requirements for Measuring an Instrument	253
	5.2.2 Methods of Measurement	253
5.3	Classification of Measuring Instruments	253
	5.3.1 Advantages of Electronic Measurement	256
5.4	Principle of Operation Electrical Measuring Instruments	256
5.5	Functional Elements of a Measuring System	257

5.6	Static Characteristics of a Measurement System	258
5.6.1	Comparison of Analog and Digital Instruments	259
5.6.2	Advantages of Digital Instruments over Analog Instruments	260
5.7	Essential Requirements of Indicating Type Instruments	260
5.7.1	Controlling Devices in Measuring Instruments	262
5.7.1.1	Comparison of Gravity and Spring Control	263
5.7.2	Damping Devices in Measuring Instruments	264
5.8	Moving-iron Attraction Type Instrument	267
5.9	Repulsion Type Moving-iron Instrument	269
5.10	Advantages & Disadvantages of MI Instruments	270
5.11	Permanent-magnet moving-coil (PMMC) instrument	270
5.12	Voltmeter	275
5.13	Ammeter	276
5.13.1	Differences between the Voltmeter and Ammeter	276
5.14	Ranges in D.C. Ammeters and Voltmeters	276
5.15	Measurement of Current	277
5.16	Measurement of Voltage	279
5.17	Measurement of Power Energy	282
5.17.1	Construction and Working of a Dynamometer Wattmeter	283
5.17.2	Construction and Working of an Induction Wattmeter	284
5.17.3	Construction and Working of a Single-Phase Energy Meter	285
5.17.4	Errors in Moving Iron Instruments	287
5.17.5	Errors in 1-phase Energy Meter	287
5.17.6	Common Errors in the Dynamometer Instruments	288

5.18	Bridge Circuit	289
5.19	Measurement of Resistance	290
5.19.1	Wheatstone Bridge	290
5.19.2	A.C. Bridge	292
5.20	Inductance Comparison Bridge	293
5.21	Capacitance Comparison Bridge	293
5.22	Cathode Ray Oscilloscope	295
5.22.1	Components of Cathode Ray Oscilloscope	296
5.22.2	Principle of Operation of CRO	297
5.23	Cathode Ray Tube	298
5.23.1	Uses of Cathode Ray Oscilloscope	301
5.24	Electrostatic Deflection Sensitivity of CRO	302
5.25	Magnetic Deflection in a Cathode Ray Tube	304
5.26	Comparison between Deflection Methods	305
5.27	Applications of CRO	306
5.28	Solved Problems	306
5.29	Outcomes	313
5.30	Summary	314
5.31	Review Questions	314
5.32	Multiple Choice Questions	316

