

# INTRODUCTION TO PRACTICAL RADIO

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THE MACMILLAN COMPANY · NEW YORK

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PRINTED IN THE UNITED STATES OF AMERICA

Fourth Printing, 1953.

## *Preface*

Radio is such an extensive subject that it would require many volumes to cover it thoroughly. Such an undertaking would be a tremendous task and no such set of books has been written, although there are many covering its various phases.

The author has long felt the need for a single text dealing with the basic fundamentals of radio that could be used as a steppingstone to more advanced books on the subject. This text was written with that thought in mind. No attempt has been made to cover the whole subject of radio but rather to limit the text to the initial principles that any student must first learn before he takes up the more advanced phases.

By confining the text material to first principles, the author has been able to cover each step adequately. In addition, the necessary mathematical tools are supplied as needed, in the belief that they will be of material aid to those lacking the prerequisites necessary to study most radio texts.

It is hoped that more advanced students will find the book an extensive reference and an invigorating "refresher" in relearning the many fundamental details.

The author wishes to express his appreciation to Dean E. H. Flath of the Southern Methodist University Engineering School, to Walter J. E. Schiebel, Director of the Dallas Public Evening School, and to many others, too numerous to mention, for their constant encouragement and many helpful suggestions. He is likewise indebted to his many students and other friends for the answers to the problem exercises and for detailed work in checking several chapters of the manuscript.

The author is deeply indebted and grateful to his wife for typing the manuscript and for her many suggested improvements.

DURWARD J. TUCKER

## *Symbols Used in Text*

$A$	Cross-sectional area
a-c	Alternating-current
$B$	Flux density
$C$	Capacitance
d-c	Direct-current
$e$	Instantaneous voltage; also, Napierian system base where $e = 2.71828\ldots$
$E$	Voltage
$E_{eff}$	Effective voltage
$E_{max}$	Maximum voltage
$f$	Frequency
$F$	Magnetomotive force measured in Gilberts
$H$	Magnetizing force in Oersteds
$i$	Instantaneous value of current
$I$	Current
$I_{eff}$	Effective current
$I_{max}$	Maximum current
$k$	Coefficient of coupling between two coils
$K$	Constant determined by the properties of the magnetic material; also, dielectric constant of a condenser dielectric
$l$	Length
$L$	Inductance
$M$	Mutual inductance between two coils
$N$	Number of turns in a coil
$p$	Instantaneous power
$P$	Electric power
$P_{avg}$	Average power
$P_h$	Hysteresis core loss in watt-seconds per cubic centimeter per cycle
$P_{max}$	Maximum power
$R$	Resistance in ohms
$\mathcal{R}$	Reluctance
$t$	Thickness of dielectric
$W$	Watts (unit of electrical power)
$W_h$	Hysteresis core loss in watt-seconds per cubic centimeter per cycle

$x$	Horizontal axis
$X$	Reactance
$X_C$	Capacitive reactance
$X_L$	Inductive reactance
$y$	Vertical axis
$Z$	Impedance
$=$	Equal sign
$\neq$	Unequal sign
$[]$	Brackets
$\{\}$	Braces
$\sqrt{\quad}$	Radical sign
$\phi$	Total number of lines of force (Maxwells)
$\mu$	Permeability
$\pi$	Ratio of Circumference of circle to Diameter (3.1416.....)
$\rho$	Resistivity of metallic conductor
$\infty$	Infinity

## INTRODUCTION TO PRACTICAL RADIO

## *Contents*

### *Chapter I. Introduction*

1. Relation to Electricity	1
2. Building Stones of Radio	1
3. Mathematics	2
4. Examples and Problems	2
5. Conclusion	2

### *Chapter II. Elementary Electricity*

6. Introduction	4
7. Molecule and Atom	4
8. Electron	4
9. Electrical Charges	5
10. Electric Current	5
11. Voltage	6
12. Resistance	6
13. Resistance Properties of Materials	6
14. Ohm	7
15. Conductors and Insulators	10
16. Electrical Circuits	11
17. Resistance Devices	11
18. Electrical Symbols	12
19. Slide Rule	12

### *Chapter III. Ohm's Law*

20. Arithmetic	15
21. Algebra	15
22. Mathematical Symbols	15
23. Coefficients	16
24. Positive and Negative Numbers	16
25. Laws of Positive and Negative Numbers	17
26. Zero	17

27. Equal Signs	18
28. Equations	18
29. Equation Rules	18
30. Ohm's Law	21
31. Law of Signs	24
32. Grouping Signs	24
33. Exponents	25
34. Law of Exponents for Multiplication	25
35. Law of Exponents for Division	26
36. Radicals	28
37. Addition and Subtraction of Radicals	28
38. Multiplication of Radicals	28
39. Division of Radicals	29
40. Fractions	29
41. Fractional Exponents	30
42. Powers of Ten	31

#### *Chapter IV. Resistance Circuits*

43. Division of Current	35
44. Currents in Resistance Branches	37
45. Voltage Drop	38
46. Series Circuits	40
47. Series Parallel Circuits	42
48. Parallel Connected Resistors	43
49. Conductance	49

#### *Chapter V. Direct-current Power*

50. Work	54
51. Power	54
52. Heating Effect of Current	55
53. Other Expressions of Power	56
54. Efficiency	57
55. Power Used by Resistors	58
56. Variable Resistors	59
57. Sources of D-c Power	60
58. Batteries	60
59. Series Connected Batteries	62
60. Parallel Connected Batteries	63
61. Motor Generators and Vibrators	63
62. Alternating-current Rectifiers	64



## CONTENTS

ix

63. Internal Resistance of Power Source	66
64. Voltage Regulation	66

### *Chapter VI. Equipment Wiring*

65. Point-to-point Wiring	68
66. Form Wiring	72
67. Simple Circuits	73
68. Advanced Circuits	75
69. Summary	81

### *Chapter VII. Kirchhoff's Laws*

70. First Law	82
71. Second Law	83
72. Further Studies of Mathematics	84
73. Addition and Subtraction	85
74. Multiplication	86
75. Division	87
76. Factoring	89
77. Simultaneous Equations	90
78. Graphical Solution	90
79. Addition and Subtraction Solution	90
80. Substitution, Comparison, Determinants	92
81. Simple Applications of Kirchhoff's Laws	94
82. Determination of Direction of Current Flow	97
83. Extended Applications of Kirchhoff's Laws	100
84. Superposition Solution of Circuits	106

### *Chapter VIII. Magnetism*

85. Magnetic Field	111
86. Magnetic Properties of Materials	112
87. Magnetic Materials	112
88. Theory of Magnetism	113
89. Magnetic Poles	113
90. Magnetic Lines of Force	114
91. Magnetic Fields of Magnets	115
92. Practical Uses of Magnets	115
93. Logarithms	116
94. Different Bases	117
95. Logarithm Tables	117

96. Characteristic and Mantissa	117
97. To Find the Logarithm of a Given Number	119
98. Antilogarithm	121
99. Multiplication by Logarithms	121
100. Division by Logarithms	122
101. Cologarithms	123
102. Logarithm of Powers and Roots	123
103. Change of Logarithm Base	124

### *Chapter IX. Electromagnetism*

104. Magnetic Field Around a Conductor	126
105. Direction of Current Flow	127
106. Left-hand Rule	127
107. Electromagnetism	128
108. Permeability	129
109. Headphones	130
110. Speakers	131
111. Relays	132
112. Magnetomotive Force	133
113. Magnetizing Force	135
114. Reluctance	137
115. Ohm's Law for Magnetic Circuits	139
116. Flux Density	141
117. Core Saturation	141
118. Magnetic Shielding	143
119. Residual Magnetism	145
120. Hysteresis	146
121. Hysteresis Losses	147
122. Magnetic-circuit Calculations	149

### *Chapter X. Alternating Current*

123. Alternating Current	152
124. Alternation and Cycle	152
125. Frequency	153
126. Angles	154
127. Triangles	155
128. Trigonometry	155
129. Right Triangles	155
130. Relation of Sides to Angles	157
131. Trigonometric Functions	158

# CONTENTS

xi

132. Table of Trigonometric Functions	160
133. Given the Angle—To Find the Function	161
134. Given the Function—To Find the Angle	163
135. Signs in Different Quadrants	164
136. Sine, Cosine, and Tangent of Angle in Different Quadrants	164
137. Radian	165
138. Sine Wave Graph	167
139. Waves	168
140. Alternating-current Wave	168
141. Alternating-current Voltage Wave	169
142. Wave Additions	170
143. Complex Waves	174
144. Generation of Alternating Current	175
145. Effect of Alternating Current and Voltage	176
146. Ohm's Law for R in an A-c Circuit	179
147. Alternating-current Power in Resistances	179
148. Vectors	181
149. Addition of Vectors	182
150. Graphical Addition of Vectors	182
151. Vector Components	184
152. Addition of Vector Components	184
153. Current and Voltage Vectors	187
154. Phase and A-c Power	187

## *Chapter XI. Electrical Instruments*

155. Electrical Measurements	192
156. D'Arsonval Movement	192
157. Current Measuring D-c Instruments	195
158. Voltage Measuring D-c Instruments	195
159. Direct-current Instrument Movement Types	196
160. Direct-current Milliammeters	196
161. Shunts	197
162. Direct-current Voltmeter	198
163. Multipliers	199
164. Care of D'Arsonval Type Instruments	201
165. Galvanometer	201
166. Measurement of Resistance	202
167. Wheatstone Bridge	203
168. Ohmmeter	204
169. Volt-ohmmeter	206

170. Measurement of Power	206
171. Alternating-current Measurements	206
172. The Effect of Frequency	208
173. Electrodynamometer Type Instrument	208
174. Iron-vane Type Instruments	210
175. Hot-wire Type Instrument	212
176. Thermocouple Type Instrument	213
177. Rectifier Type Instrument	214
178. Alternating-current Instrument Scales	214
179. Conclusions	216
180. Other Electrical Measuring Equipment	216

### *Chapter XII. Inductance*

181. Lenz's Law	218
182. Inductance	219
183. Self-inductance	219
184. Determination of Self-inductance	219
185. Unit of Inductance	220
186. Mutual Inductance	222
187. Determination of Mutual Inductance	223
188. The Transformer	224
189. Transformer Properties	224
190. Transformer Losses	227
191. Inductances Connected in Series-parallel	227
192. Rate of Change of Current	228
193. Phase Relation of $E$ and $I$ for Inductance	229
194. Inductive Reactance	230
195. Power in an Inductance	231

### *Chapter XIII. Capacitance*

196. The Condenser	234
197. The Electric Field	234
198. Dielectric Constant	238
199. Dielectric Materials	238
200. Energy-storing Properties of a Condenser	239
201. Unit of Capacitance	240
202. Capacitance of a Condenser	240
203. Condensers Connected in Series-parallel	241
204. Rate of Change of Voltage	242
205. Phase Relation of $E$ and $I$ for a Condenser	242

## CONTENTS

xiii

206. Capacitive Reactance	243
207. Power in a Condenser	244
208. Condenser Properties	245
209. Variable Condensers	246
210. Mica Condensers	246
211. Paper Condensers	246
212. Electrolytic Condensers	247

### *Chapter XIV. Impedance*

213. Determination of Impedance	250
214. Alternating-current Voltage and Current in Impedance Circuits	251
215. Phase of E-I for Series, Parallel Circuits	251
216. Resistance and Inductance in Series	251
217. Resistance and Capacitance in Series	253
218. Resistance, Inductance, and Capacitance in Series	255
219. Series Resonance	256
220. Effect of Resistance on Series Resonance	257
221. Resistance and Inductance in Parallel	259
222. Resistance and Capacitance in Parallel	261
223. Resistance, Inductance, and Capacitance in Parallel	262
224. Parallel Resonance	263
225. Effect of Resistance on Parallel Resonance	264
226. Series, Parallel A-c Circuits	265
227. Impedance Matching	265

### *Appendix*

Greek Alphabet	272
Table V (Logarithms)	273
Table VI (Trigonometric Functions)	292
Table VII (Powers—Roots—Reciprocals)	294
Mathematical Glossary	312
Electrical Glossary	314
Index	319

## CHAPTER I     *Introduction*

**1. Relation to Electricity.** The first thing that the student of radio must realize is that radio is not a separate science apart from electricity. Actually, it is but a specialized subject of electricity. To understand radio fully, one must first fully master the fundamentals of electricity.

It may seem to the student just starting the study of radio that the time and space in this text devoted to the study of the elements of electricity is excessive. Especially may this be true where the student has already covered the material in other texts. So much in radio depends upon a thorough knowledge of the fundamentals of electricity, however, that this material should be an excellent review for those who have studied it before and provide a suitable foundation in electricity for those covering it for the first time.

It is a waste of time to try to learn radio without first acquiring some knowledge of the basic principles underlying electricity. These are the abc's of radio, and the student must fully understand each one before progressing to the next. No attempt has been made to "pad" the text. Only those parts of electricity that are used over and over again are included.

**2. Building Stones of Radio.** Many believe that radio is quite difficult to learn and beyond their ability. In most cases, this can be traced to an improper approach to the subject. Here again is an example of why *first things must come first*. Lack of knowledge on the part of the student as to what to study first and how to choose from the maze of radio texts available contributes to his confusion.

The student will soon find that radio has many building stones fashioned from three principal sources: namely, resistance, inductance, and capacitance. These three quantities may be compared to wood, brick, and cement used extensively by the building industry. One knows that many building materials are formed from these basic

substances. Likewise, many circuit elements are formed from resistance, inductance, and capacitance. The student will find a generous supply of pictures throughout the book showing many typical radio parts. These should be of material assistance in helping the student familiarize himself with the many different pieces of radio apparatus.

**3. Mathematics.** Students are often concerned with what knowledge of mathematics will be required in the study of radio.

There is no doubt that the use of mathematics is very helpful in acquiring a full understanding of radio principles. The choice of the kind of mathematics and the extent to which it is used in a text should be governed by the text material and the student. Naturally, as the student progresses farther and farther into the subject of radio, a greater knowledge of mathematics will be required.

The author has striven to keep in mind that this is a course in radio and not one in mathematics. The author is a firm believer in setting down the material, not only in the simplest mathematical form, but also in the plainest language possible.

Only those phases of mathematics deemed absolutely necessary are included in this text. They are placed, like the workman's tools, at the student's side at the right points in the book where he will need them. No attempt has been made to make the mathematical sections complete from a mathematical standpoint. Only enough mathematical material for a proper understanding of the radio material is included.

**4. Examples and Problems.** Numerous examples are included in order to familiarize the student fully with the principles involved.

Problem exercises have been inserted as near the theoretical treatment of a subject as possible. The student should solve these problems and be sure that he understands each section before passing on to new material. Answers are provided at the end of each chapter for the convenience of the student in checking his work since, in many instances, the text will be self-taught.

**5. Conclusion.** Study and experience in radio as a professional Radio Engineer and as a teacher, have taught the author that *there is no "short cut" to learning radio*. The student will do well to profit by this experience if he is to master the subject of radio most effectively in the shortest possible time.

At this point, the student is most likely to ask: "For what will this text prepare me?" This is a pertinent question but one which is difficult to answer. Many, beginning the study of radio are surprised, confused, disappointed, and discouraged that all the secrets of radio cannot be found between the two covers of one book. Many visualize the study of radio in the same light as the study of typing, shorthand, bookkeeping, and other business courses. They visualize progress in Radio Engineering as easy as gaining speed from week to week in typing. Such thoughts are not of Radio Engineering, but are of radio mechanics or a "screw-driver and pliers" knowledge in radio. The mechanics of testing and changing tubes, setting up amplifiers, learning the technique of soldering and wiring, making replacements of charred and burned parts and other similar mechanical details can be learned within a few weeks. This is a most essential part of the radio industry but should never be confused with the Radio Engineering Profession.

The author has started at the very beginning and has striven to make the text *complete within itself* in order that the student may acquire a firm foundation in the fundamental principles of radio without having to refer to other texts for additional material. After finishing the text, the student should have acquired sufficient knowledge to take up the study of other books dealing with the more advanced phases of radio.

## REVIEW QUESTIONS

1. Why is an understanding of the basic principles of electricity necessary in order to learn radio?
2. Is a thorough knowledge of mathematics helpful in the study of radio? Why?
3. What are the advantages of providing the proper mathematical tools along with the radio material?
4. Why are problem exercises helpful in the study of a subject such as radio?
5. Compare the study of radio to the study of typing, radio code, and riveting.



## CHAPTER II     *Elementary Electricity*

**6. Introduction.** The engineering development of electrical equipment, since the turn of the century, has done much to add to the comfort of man. Many new branches of electricity have been developed. Radio is one of these, and its development has added much to the present knowledge of electricity.

Despite the wealth of knowledge of the behavior and characteristics of electricity, its exact nature is not too well defined. One may be surprised to learn that electricity is a part of matter itself.

**7. Molecule and Atom.** One is not accustomed to think in terms of units as small as the *molecule* or *atom* or their relation to matter, but in order to understand electricity better, it is necessary to go this far and farther. Matter is best known from many common materials, such as wood, linoleum, and cotton. Each material is determined by the *character of the molecules* of which it consists. Matter can be broken up into still smaller particles. The molecule can be broken down into *atoms*. *Two or more atoms are required to form a molecule.*

The many thousands of types of matter are formed from less than one hundred substances called *elements*. *The smallest unit of an element is an atom.* The structure of the atom determines whether matter is iron, gold, silver, or some other element. If the structure of the atom could be readily changed, then one element could be made into another, such as changing iron to gold. No such set of conditions exists. The atom vigorously opposes any attempt to break it up into smaller parts.

**8. Electron.** Scientists have been able to find out many things about the actual structure of the atom. Principle of these is that all atoms are composed of positive and negative charges of electricity. *Positive* charges of electricity are called *protons* and *negative* charges of electricity are called *electrons*. The number of positive and negative parti-