

Contents

Preface	ix
List of principle symbols	xii
Acknowledgements	xv
1 Basic concepts	1
1.1 Radiation	1
1.2 The Hertzian dipole	5
1.3 Hertzian dipole polar pattern	8
1.4 The Hertzian dipole reconsidered	9
References	18
Problems	18
2 Electromagnetic wave propagation and power flow	20
2.1 Maxwell's equations basics	20
2.2 Plane wave propagation in space	24
2.3 Power flow	28
2.4 Antenna directivity, power gain and efficiency	31
References	38
Problems	39
3 Linear dipole antennas	40
3.1 Dipole antenna of finite length	40
3.2 Current distribution on a finite-length dipole (far-field effect of a sinusoidal current)	42
3.3 Dipole antenna radiation resistance	46
3.4 Short dipole antenna	47
3.5 Gain of a half-wave dipole relative to a Hertzian dipole and power transfer	49

References	54
Problems	55
4 Antenna array techniques	56
4.1 Radiation patterns for two antennas	56
4.2 One-dimensional linear arrays and far-field transformation	60
4.3 Two-dimensional stacked arrays	70
4.4 Non-uniform current excitation array	72
4.5 Antenna input impedance	76
4.6 Induced-emf method and mutual coupling	79
4.7 End-fire array example with mutual coupling	85
4.8 Dipole antennas in relation to a ground plane	89
References	92
Problems	93
5 Systems and characterisation considerations	94
5.1 Effective length of an antenna and reciprocity	95
5.2 Antenna aperture and the free-space link equation	95
5.3 Effective temperature of an antenna and noise effects	101
5.4 Polarisation of plane electromagnetic waves	108
5.5 Distance to antenna far field	112
5.6 Clearance	114
5.7 Antenna characterisation principles	117
References	126
Problems	126
6 Antenna-matching techniques	128
6.1 Transmission line principles	129
6.2 Lumped matching circuits	136
6.3 Reactive matching circuits	142
6.4 Balun matching	148
6.5 Power splitting/combining networks	151
6.6 Impedance matching and the Smith chart	153
References	161
Problems	162
7 Basic antenna types	164
7.1 Small rectangular loop antennas	165
7.2 Slot antennas	167
7.3 Yagi antennas	170
7.4 Rectangular microstrip patch antennas	172
7.5 Reflector antennas	177
7.6 Helical antennas	182
7.7 Horn antennas	186
7.8 Straight-wire travelling-wave antennas	187

7.9	Planar inverted-F antennas	190
7.10	Dielectric resonator antennas	192
7.11	Reflectarray antennas	193
7.12	Equi-angular spiral antennas	195
7.13	Fractal antennas	197
	References	198
	Problems	200
8	Appendices	201
8.1	Linear array factor program	201
8.2	Reciprocity in a two-port network	211
8.3	Noise equivalent bandwidth, minimum discernible level and noise temperature measurement	212
8.4	Scattering parameter matrix	214
	Bibliography	217
	Glossary of terms	221
	Index	225