

Contents

Content Summary — V

**An Epigram for Electromagnetic Field Theory Teaching Series by Professor
Liang Changhong — VII**

Author's Biography — IX

Preface — XI

List of Figures — XXI

- 1 Self-action energy in electrostatic field — 1**
 - 1.1 Introduction — 1
 - 1.2 Self-action energy in the electrostatic field — 2
 - 1.2.1 Total electrostatic self-action energy of uniformly distributed charges cube $2a \times 2a \times 2a$ — 3
 - 1.2.2 Total electrostatic self-action energy of the charge system of any shape with volume V — 4
 - 1.3 Field calculation and source calculation — 5
 - 1.3.1 Field method — 6
 - 1.3.2 Source calculation method — 7
 - 1.4 Summary — 9
 - Q&A — 9
 - Recommended scholar — 12
 - Appendix — 13
- 2 Corresponding research between time-harmonic field and complex field — 19**
 - 2.1 Introduction — 19
 - 2.2 The complex field representation of time-harmonic field in first-order quantity — 20
 - 2.2.1 The criterion for the representation of real parts — 20
 - 2.2.2 Calculus criterion — 20
 - 2.2.3 Constitutive operator — 21
 - 2.3 Second-order quantity and complex field representation of the time-harmonic field — 21
 - 2.4 Three main theorems — 24

2.4.1	Poynting theorem — 24
2.4.2	The Foster theorem for lossless one-port system — 24
2.4.3	Lorentz's reciprocity theorem — 25
2.5	Summary — 26
	Q&A — 26
	Recommended scholar — 29
3	Transformation and unification of electrostatic field and constant current field — 33
3.1	Introduction — 33
3.2	The transformation and unification of electrostatic field and constant current field — 34
3.3	Paradox of Poynting vector $\vec{S}$ — 37
3.4	Summary — 38
	Q&A — 38
	Recommended scholar — 43
4	Charge multipoles and current multipoles — 45
4.1	Introduction — 45
4.2	Generalized taylor expansion of $f(R)$ — 45
4.3	Charge multipoles — 46
4.4	Matrix expression of multipoles — 49
4.5	Current multipoles — 50
4.6	Four-dimensional current multipoles in the theory of relativity — 53
4.7	Summary — 53
	Q&A — 53
	Recommended scholar — 57
5	Polarization of electromagnetic wave and its applications — 59
5.1	Introduction — 59
5.2	Elliptically polarized wave — 59
5.3	Polarization conversion and matrix representation — 65
5.4	Engineering applications of polarization — 68
5.5	Summary — 68
	Q&A — 69
	Recommended scholar — 71
6	Conservation of charge and conservation of current — 73
6.1	Introduction — 73
6.2	Conservation of charge — 74
6.3	Conservation of current — 76

6.4	Current–charge conservation — 77
6.5	Examples of application — 77
6.6	Summary — 79
	Q&A — 79
	Recommended scholar — 84
	Appendix — 86
7	Electromagnetic reciprocal symmetry and lossless symmetry — 89
7.1	Introduction — 89
7.2	Lorentz reciprocal symmetry — 90
7.3	Hermite lossless symmetry — 92
7.3.1	Scalar energy inner product — 92
7.3.2	Vector energy (power) inner product — 93
7.4	Network-type foster theorem, generalized inertia — 95
7.5	Electromagnetic reciprocal symmetry and lossless symmetry — 97
7.6	Summary — 99
	Q&A — 99
	Recommended scholar — 103
8	Electromagnetic symmetry and symmetry operator — 107
8.1	Introduction — 107
8.2	Quadratic symmetry — 107
8.2.1	Lossless Symmetry — 107
8.2.2	Reciprocal Symmetry — 109
8.2.3	Geometric reciprocal symmetry — 110
8.2.4	Compound symmetry — 111
8.3	Linear symmetry — 112
8.3.1	Geometric symmetry — 112
8.3.2	Reciprocal symmetry — 113
8.3.3	Anti-reciprocal symmetry — 113
8.4	Symplectic inner product and electromagnetic symplectic orthogonality — 114
8.5	Summary — 115
	Q&A — 116
	Recommended scholar — 118
9	Plane image method and active conformal mapping — 121
9.1	Introduction — 121
9.2	Generalized model of the plane dielectric image — 121
9.1.1	$\epsilon_2 \rightarrow \infty$ Equivalent conductor — 123
9.1.2	$\epsilon_2 \rightarrow 0$ Equivalent magnet — 124

9.3	Active Conformal Mapping of the Conducting Cylinder —	124
9.3.1	Grounded conductor cylinder —	124
9.3.2	Ungrounded conductor cylinder —	126
9.3.3	Dual problem of the cylinder —	128
9.4	Active conformal mapping of the complex conductor —	129
9.4.1	There exist charges at position h between infinite double plates —	130
9.4.2	There exist line charges at the center between semi-infinite double plates —	131
9.5	Summary —	132
	Q&A —	133
	Recommended scholar —	138
10	Electromagnetic loss —	141
10.1	Introduction —	141
10.2	Three theorems —	141
10.3	Loss evaluation —	145
10.3.1	The condition evaluation of loss —	145
10.3.2	The geometric evaluation of loss —	147
10.3.3	The phase evaluation of loss —	148
10.4	Characteristics of lossy system —	149
10.4.1	The openness of system —	149
10.4.2	The coupling of field quantities —	149
10.4.3	The encroachment of information —	149
10.4.4	The directivity of conversion —	149
10.5	Difficulties aroused by electromagnetic loss —	150
10.5.1	The complex boundary conditions —	150
10.5.2	The difficult mode theory —	150
10.5.3	The blurred boundary between transmission mode and cut-off mode —	151
10.6	Summary —	151
	Q&A —	151
	Recommended scholar —	160
11	Complex parameter and complex theorems in electromagnetic theory —	163
11.1	Introduction —	163
11.2	Complex frequency —	164
11.3	Complex phase angle —	164
11.4	Complex frequency electromagnetic theorem —	167

11.4.1	Complex frequency Poynting theorem — 167
11.4.2	Complex frequency foster theorem — 169
11.5	Lossless transmission lines with arbitrary load — 172
11.6	Summary — 174
	Q&A — 175
	Recommended scholar — 179
12	Complex operator ∇ and 2D static field — 181
12.1	Introduction — 181
12.2	Complex operator ∇ — 182
12.3	Complex operator integral theorem — 184
12.4	Complex partial derivative — 185
12.5	Complex operator form of 2D electrostatic field — 186
12.6	Complex operator form of 2D steady magnetic field — 188
12.7	Summary — 189
	Q&A — 189
13	New network theory of electromagnetic waves in multilayered media — 195
13.1	Introduction — 195
13.2	Basic model — 195
13.3	Special angle — 198
13.3.1	Brewster's angle θ_B of no reflection — 198
13.3.2	Critical angle θ_c in the Case of Total Reflection — 198
13.4	Electromagnetic wave transmission [C] network — 199
13.4.1	Oblique incidence of parallelly polarized waves — 200
13.4.2	Oblique Incidence of Perpendicularly Polarized Waves — 201
13.4.3	Normal incidence — 202
13.4.4	Unified [C] network — 202
13.4.5	Wave transmission section $[C_i]$ — 202
13.5	Engineering applications — 203
13.6	Energy conservation — 205
13.7	Summary — 206
	Q&A — 206
	Recommended scholar — 214
14	Matrix transformation in electromagnetic theory — 215
14.1	Introduction — 215
14.2	Two-dimensional coordinate rotation and transformation to polar coordinate matrix — 216

14.3	Three-dimensional coordinate matrix transformation —	218
14.3.1	Coordinate plane rotation and its matrix transformation to cylindrical coordinate —	218
14.3.2	Spherical Coordinate Rotation and Its Matrix Transformation to Spherical Coordinate —	219
14.3.3	Matrix Transformation of Orthogonal Curvilinear Coordinates —	220
14.3.4	Matrix transformation of operator ∇ —	222
14.4	Matrix transformation from longitudinal field component to transverse field component —	223
14.5	Summary —	225
	Q&A —	225
	Recommended scholar —	229
15	Minimum directivity challenge of electromagnetic radiation —	231
15.1	Introduction —	231
15.2	Maxwell's equations do not have isotropic solutions —	231
15.3	Minimum directivity antenna —	233
15.4	Minimum directivity array —	235
15.5	Summary —	239
	Q&A —	239
	Recommended scholar —	245
	Appendix A y -direction dipole parameters and electric field $\vec{E}_{\theta'}$ —	246
	Appendix B The phases of two-dimensional eight-element —	248
16	Mysteries of Fermat's principle —	251
16.1	Introduction —	251
16.2	Expression of the law of nature —	252
16.3	Minimum or maximum —	253
16.4	Phase velocity v_p or group velocity v_g —	255
16.5	Energy E and actuating quantity s —	258
16.6	Physical quantity or space —	259
16.7	Least action principle —	260
16.8	Summary —	261
	Q&A —	262
	Recommended scholar —	272
17	Electromagnetic inertia —	275
17.1	Introduction —	275
17.2	Electromagnetic inertia —	277

17.3	Electrostatic inertia — 278
17.3.1	Potential φ distribution inertia — 278
17.3.2	Electrostatic charge Σ distribution inertia — 279
17.4	Green function and electrostatic inertia — 280
17.5	Any antenna element cannot constitute an ideal wavelet source — 281
17.6	Summary — 282
	Q&A — 282
	Recommended scholar — 286
18	Beauty of electromagnetic theory — 289
18.1	Introduction — 289
18.2	The simple beauty of electromagnetic theory — 289
18.3	Symmetry beauty of electromagnetic theory — 291
18.4	The beautiful transformation of electromagnetic theory — 293
18.4.1	The mutual conversion of electric field and magnetic field — 293
18.4.2	The mutual transformation between space-varying and time-varying — 293
18.5	The beautiful unity of electromagnetic theory — 294
18.6	The duality of beauty — 295
18.7	Summary — 296
	Q&A — 296
	Recommended scholar — 300
19	Some thoughts on the electromagnetic theory — 301
19.1	Introduction — 301
19.2	Symmetry and asymmetry — 301
19.2.1	The “first handshake” between electricity and magnetism — 302
19.2.2	Faraday’s symmetry concept — 302
19.2.3	The “second handshake” between electricity and magnetism — 303
19.2.4	The research of symmetry never ends — 305
19.3	Lossless and lossy — 305
19.3.1	The concept of electromagnetic loss — 305
19.3.2	Lossless symmetry — 309
19.3.3	Uniqueness theorem of losslessness — 315
19.3.4	Loss and attenuation — 316
19.3.5	Ambiguity of loss — 318
19.3.6	Stability of loss — 318
19.3.7	Inequality of loss — 319

XX — Contents

19.3.8	Paradox of loss —	320
19.3.9	Lossy and lossless characteristic quantities —	321
19.3.10	Two symmetries —	322
19.3.11	Least action principle of lossy variation —	323
19.4	Four-dimensional Minkovski space and $\bar{L}_6$ —	325
19.5	Static fields and alternating fields —	329
19.6	Essence of discipline development lies in innovation —	331
19.6.1	Emphasis on the feature study of electromagnetic theory —	332
19.6.2	Long-term study and constant practice —	333
19.6.3	Seeking difference and innovation —	334
19.6.4	Seeking common ground and unification —	334
19.6.5	Developing and recreating —	335
19.7	Summary —	336
20	Teaching notes —	337
20.1	Knowledge is foundation —	337
20.2	The key is “Heart” —	340
20.2.1	Dedication —	340
20.2.2	Responsibility —	342
20.2.3	Commitment —	342
20.2.4	All boils down to love —	343
20.3	Innovation is highlighted —	343
20.4	Comprehension is the key —	348
20.5	The ultimate goal is “The Way” —	350

References — 351

Index — 355