

Index

- admittance, of antenna and arrays. *See* under name of antenna or array
- apparent load, 481, 494, 499, 535
- driving-point, 2
- of load, terminating line, 481
- per unit length, 477; of uniform line, 479
- phase-sequence, three-term, 62, 110; two-term, 111
- self- and mutual, of circular array, 86, 88 ff;
 measurement of, 502–8; of two-element array, 65, 73
- See also* impedance
- Aharoni, J., xviii
- antenna, cage, 108
- electrically short, 11–13
- infinite, 453, 454, 465 ff
- simplified linear, 1–3
- with sinusoidal current, 13–20; currents and charges in, 13, 18–20, graphs of, 18–20; field of, 13–16; impedance of, 16–18; relation to center-driven antenna, 18–20
- top-loaded, 311 ff
- with triangular current, 11–13; field pattern of, 12; power pattern of, 12
- See also* Beverage antenna; cylindrical antenna; dipole; horizontal dipole; horizontal-wire antenna; loop; monopole; microstrip patch antenna; receiving antenna; short antenna; terminated insulated antenna; vertical antennas; vertical dipole
- antenna system, 1, 2
- array, broad-band, 215; conventional analysis for, 112, 113; definition of, 54; directional, 353, 356–9; general, notation for, 379–85, 390, 391; omnidirectional, 359–63; resonant non-circular, 407, 408; uniform, 124; *see also* arrays; arrays with horizontal and vertical elements; arrays with staggered elements; arrays with unequal elements; broadside array; circular array; collinear array; couplet; curtain array; endfire array; large circular array; log-periodic array; parasitic array; planar array; receiving array; resonant array with two driven elements; scanned array; three-dimensional array; Yagi–Uda array
- array factor, of circular array, 88; for *m*th phase-sequence resonance, 405, 406
- of curtain array, 124, 129–31
- normalized, of three-element array, 125
- of resonant non-circular array, 407, 408
- of uniform array, 124
- array theory, conventional, 112, 113; comparison with two-term theory, 112, 113, 123–37; limitations of, 113, 119, 124
- three-term. *See* three-term theory
- two-term. *See* two-term theory
- arrays, circuit equations for, 112, 503; of horizontal dipoles and vertical monopoles over ground plane, programming aspects of, 388–90; practical, 288, 289
- arrays with horizontal and vertical elements, over earth or sea, 359 ff; directional, diagram of, 364; electric far field of, 364
- omnidirectional, diagram of, 361; electric far field of, 363; impedances of, 360; radiation efficiency of, 362; total power radiated by, 362
- with radial array of insulated wires in earth or sea, 365
- for spherical earth or sea, 365–9
- arrays with staggered elements, 241 ff; admittances of, 252; approximations of currents in, 247–9; currents in, 244, 247–9; driving-point currents in, 252; evaluation of coefficients for, 249–53; far-zone fields of, 253–5; typical elements in, 243; vector potential on *k*th element of, 244, 245; vector potential differences for, 245–7; *see also* arrays with two staggered elements; planar array; three-dimensional array
- arrays with two staggered elements, 256–63; currents when symmetrically and antisymmetrically driven, graph of, 263; diagram of, 256; self- and mutual impedances of, table of, 260; symmetrical and antisymmetrical admittances of, table of, 258; symmetrical and antisymmetrical impedances of, graphs of, 258, 259
- arrays with unequal elements, 153 ff; admittances of, 214, 215; currents in, 214; when elements differ greatly in length, 208 ff; experimental verification of theory of, 239, 240; impedances of, 215; *see also* log-periodic dipole array; parasitic array, with elements of unequal length; Yagi–Uda array

- Barzilai, G., xvii
basis functions, 24
beam width, definition of, 13
Beverage antenna, description of, 349; diagram of, 350; *see also* horizontal-wire antenna
Bontsch-Bruewitsch, M. A., xvii
boundary conditions, between air and perfect conductor, 3, 4, 6; at surface of cylindrical antenna, 20, 21; *see also* electric field, boundary conditions for
broadside array, admittances and impedances of, tables of, 579 ff
 driving conditions for, currents specified, 132; voltages specified, 137
 field patterns of, 138, 142
 resistances and reactances of, currents specified, 138–40; voltages specified, 138, 141
 See also curtain array; planar array; three-dimensional array
Brown, G. H., xvii
Brückmann, H., xvii

Carrel, R. L., 218, 238
Carter, P. S., xvii
Chang, V. W. H., 249, 256, 262, 272
charge, per unit length, 7, 478; surface density of, 4; volume density of, 3
charges, in dipoles with sinusoidal currents, graphs of, 20
Cheong, W.-M., xviii, 208, 209, 222, 229, 235, 238–40
circular array, coefficients for currents in, tables of, 539–52
 corrected two-term susceptance of, 89; graph of, 93
 currents in elements of, 83, 86
 diagrams of, 81, 393, 439
 driving-point admittances of, 88
 effect of ohmic losses in. *See* large circular array, of lossy elements
 far-zone electric field of, 87
 general description of, 79, 80
 integral equations for sequence currents in, 80–6, 107
 of large number of elements. *See* large circular array
 with one element driven, 95 ff, 396 ff
 phase-sequence currents in, 83; in terms of element currents, 87; in terms of voltages and impedances, 107
 programming aspects of, 388
 radiation patterns of, 95–103; graphs of, 101, 102, 104
 resonant spacings in, 89, 90
 self- and mutual admittances of, 86, 88–95; graphs of, 90–100; measurement techniques for, 504, 505; relations between calculated and measured, 89–95; resonances in, 89, 90; tables of, 539–52
 sequence admittances of, 86; tables of, 539–52
 sequence functions of, 86, 87
 three-term theory, for sequence admittances, 110; for sequence currents, 109, 110
 with two elements driven. *See* resonant array with two driven elements
 two-term theory, for currents, 87; for far-zone fields, 87; for sequence admittances, 86, 111; for sequence currents, 85, 111
 vector potential difference on surface of each element of, 80–2
 voltages in, driving, 86; phase relations between, 83; phase-sequence, in terms of driving voltages, 87
collinear array, two-element, currents in when symmetrically and antisymmetrically driven, graph of, 261; self- and mutual impedances of, table of, 260; symmetrical and antisymmetrical admittances of, table of, 257; symmetrical and antisymmetrical impedances of, graphs of, 258, 259
conductance. *See* admittance
continuity, equation of, 3, 8
correction for susceptance, in three-term theory, 42; in two-term theory, 49, 50, 89
coupled circuits, matrix equation for, 105, 112
couplet, currents in, in terms of driving voltages, 67; two-term formulas for, 72
 description of, 67
 driving-point admittances of, 68, 76
 field of, full-wave, 76, graph of, 78; ideal, graph of, 78
 full-wave, example of, 76–8
 See also curtain array of two elements
coupling, between transmission line and load, 476–81
coupling coefficient, capacitive, 477, 478; inductive, 477, 478
Cox, C. R., xvii
current, in antenna and arrays. *See* under name of antenna or array
 capacitive and inductive components of, 223, 227, 233
 distribution of, five-term, 249; relation to far field, 9; sinusoidal, 13–20, 31; three-term, 37, 40, 41, 160; along transmission line, 487–92; two-term, 48, 52, 87, 114 ff, 154
 driving-point, correction for, 42, 49
 even and odd, 245–9
 integral equations for, 20–3, 32, 33; properties of, 33–5, 453–5; rearranged, 36; reduced, 36–9
 in matrix form, for use in programming, 384; when $kh = \pi/2$, 390
 phase-sequence, in circular array, 84, 85, 109, 110; integral equation for, 56, 107; in matrix notation, 107, 109–11; relation to element

- currents, 64, 87; three-term, 59, 62, 63, 109, 110; in two-element array, 62, 63, 70; two-term, 70, 84, 85, 111
- sinusoidal assumption, xvii, 13, 31
- sinusoidal distribution of, in transmission line and antenna, 31
- surface density of, 4, 7, 21
- total, on center-driven dipole, 21; on thin linear antenna, 7
- transmitting and receiving parts of, 119
- volume density of, 3
- curtain array, admittances and impedances of, 121; tables of, 579–93
 - broadside. *See* broadside array
 - circuit properties of, graphs of, 139–41, 145–7
 - currents in, conventional theory, 113; two-term theory, 114–21
 - definitions, of Φ functions, 119, 120, tables of, 553–78; of Ψ functions, 117, 118, 122
 - endfire. *See* endfire array
 - far-zone electric field of, 123, 124
 - field properties of, 138, 144; graphs of, 142, 148
 - field with sinusoidal currents, 123
 - general formulas, driving voltages specified, 121; input currents specified, 121
 - integral equation for currents in, 115
 - matrix elements of, tables of, 553–78
 - matrix equations for, 119, 120
 - programming aspects of, 387, 388
 - simultaneous equations for coefficients for, 117–20
 - special case when $\beta_0 h = \pi/2$, 148–51
 - three-element example. *See* curtain array of three elements
 - two-element example. *See* curtain array of two elements
 - two-term theory of, 114 ff; when $\beta_0 h = \pi/2$, 148 ff
 - vector potential difference of, 115
- curtain array of three elements, 124 ff; beam pointing error of, 136; currents in, graphs of, 129, 130; diagram of, 114; driving-point impedances of, 126, 127; electric field of, 124, 125; full-wave elements in, 127–30; half-wave elements in, 126, 127; power in elements of, 127; scanning with, 128 ff; variation of impedance with beam angle, 134
- curtain array of two elements, analysis of, 54 ff
 - arbitrarily driven, 64–6
 - current in, three-term, 64, 66; two-term, 72, 73, 76, graphs of, 75, 77
 - diagram of, 55
 - field of, 68, 69; for couplet, 76–8
 - integral equations for phase-sequence currents of, 56; properties of, 57–9; reduction of, 59–62
 - phase-sequence admittances of, three-term, 62, 63; two-term, 70
 - phase-sequence currents in, integral equations for, 56; three-term, 62, 63; two-term, 70, graph of, 72
 - self- and mutual admittances of, three-term, 65; two-term, 73, compared with measurements, graph of, 74
 - self- and mutual impedances of, table of, 260; three-term, 65; two-term, 73
 - symmetrical and antisymmetrical admittances of, table of, 257
 - symmetrical and antisymmetrical impedances of, graphs of, 258, 259
 - vector potential difference of, 54, 55
- curve width, 498, 501, 502
- cylindrical antenna, admittance of, measured, 50
 - three-term approximation of, 40, 41; comparison with experiment, 42–4
 - two-term approximation of, 48; comparison with experiment, 49, 50; table of, 539
- boundary conditions at surface of, 20, 21, 32
- charges in, 7, 20
- current in, assumed sinusoidal distribution of, 13, 31; graphs of, 18, 19
 - three-term approximation of, compared with measurements, 41–4; derivation of, 36–40; formulas for, 40, 41; graphs of, 43, 44
 - two-term approximation of, compared with measurements, 49, 50; formulas for, 48, 49
- field factors for, approximations for $\beta_0 h \leq \pi$, 47, 48; graphs of, 47; three-term formulas for, 44, 45
- integral equation for current in, 33; rearranged, 36
- lumped corrective network for susceptance, three-term theory, 42
- two-term theory, 49, 89; comparison with measured and King–Middleton values, 50
- delta function, definition of, 2; as generator for antenna, 1
- dipole, center-driven, diagram of, 21
 - as charge or electric-field probe, 509
 - as end-load of two-wire line, 482, 483
 - sensitivity constant of, 509
 - short, complex effective length of, 510; input impedance of, 510
 - See also* horizontal dipole; vertical dipole
- dipole mode, of current, description of, 508, 509; in small loops, 511–16; tests for, 515–17, 529
- dipole moment, 12
- directional coupler, measurement method, 493, 496, 497
- directivity, absolute, definition of, 13; of electrically short antenna, 13; of Yagi–Uda array, 177, 178
 - relative, of Yagi–Uda array, 178, 179
 - vertical, of large resonant circular array, 407; with two elements driven, 414, table of, 415

- distribution curve, measurement method, 493–5, 497–9
- Dolph, C. L., xvii
- effective length, of dipole, 53, 207, 290, 292; of loop in dipole mode, 518; of short dipole, 510; of Yagi array, 208
- efficiency, radiating, 313, 314
- electric field, of antennas and arrays. *See* under name of antenna or array
- boundary conditions for, perfect conductor and air, 3, 4, 6; receiving antenna, 51; transmitting antenna, 21, 32
- of cylindrical conductor, 9
- in cylindrical coordinates, 9
- definition of, 3
- elliptically polarized, 531–4; diagram of, 531
- externally maintained, 16
- far-zone, of circular array, 87; coordinate system for, 8; of curtain array, 123, 124, 135; of cylindrical conductor, 9–11, 43–8; of three-element array, 135
- of grounded monopole, 307–9
- of infinitely thin antenna with sinusoidal current, 14, 15
- instantaneous, 10
- measurement of, 508–11
- near-zone, of electrically short antenna, 12
- in spherical coordinates, 9
- of vertical dipole over earth or sea, 292–303; graphs of, 308–10, 316–29; tables of, 308, 310
- electric moment, of dipole with sinusoidal current, 292
- electric vector, 3
- electromagnetic field. *See* electric field; magnetic field
- EMF method, for calculating impedance, 16–20, 126, 127; validity of, 17–20
- end-correction, for circular array, 89, 93; for single antenna, 49, 180; *see also* terminal-zone network
- end effects. *See* terminal zone; terminal-zone network
- endfire array, admittances and impedances of, tables of, 579 ff
- driving conditions for, currents specified, 132, 143; voltages specified, 143
- field patterns of, 144, 148, 149
- resistances and reactances of, currents specified, 145, 146; voltages specified, 147
- See also* curtain array; planar array; three-dimensional array
- equivalent circuit, for receiving antenna, 53, 207, 208
- error ratio, for loop probes, 517–20; graphs of, 522, 524; used as parameter, 520, 525, 526
- exponential integral, 40
- far field. *See* electric field, far-zone; magnetic field, far-zone, *also* under name of antenna or array
- field, of antennas and arrays. *See* electric field; magnetic field, *also* under name of antenna or array
- field characteristic. *See* field factor
- field factor, definition of, 10; of five-term current, 253, 254; of sinusoidal current, 13, graph of, 14; of three-term current, 44–8, graph of, 47; of triangular current, 11, graph of, 12
- field pattern, of antennas and arrays. *See* field factor, *also* under name of antenna or array
- Fikioris, G., 393, 394, 399, 401, 402, 414–17, 419, 444, 445, 447
- Fitch, E., xvii
- five-term theory, 241 ff; distribution of current in, 249; evaluation of coefficients in, 249–53; field patterns in, 253–5
- Freeman, D. K., 393
- Fresnel integral, definition of, 294, 450
- Galerkin’s method with pulse functions, 24 ff, 455–60, 462; sample results of, graphs of, 27–9, 458, tables of, 459
- generator, delta-function, 1, 16, 17, 21, 32, 33
- generators, continuous distribution of, 16, 17
- Grossmann, A., 392
- ground network, 303 ff; impedance of, 304, 306; *see also* arrays with horizontal and vertical elements
- Hallén’s integral equation, 21, 452
- Hansen, R. C., xviii
- Hartig, E. O., 484
- horizontal dipole, on microstrip, 372–5; electromagnetic field of, 373–5
- near planar earth or sea, 343 ff; diagram of, 344
- electromagnetic field of, in air, 343–5; in dielectric layer, 346; in earth or sea, 346; when dipole is on boundary, 347, 348
- far field of, conditions for, 348; formulas for, 348, 349
- for remote sensing, 369–72; applied to synthetic aperture radar (SAR), 370–2
- over spherical earth, 365 ff; electromagnetic field of, 367
- horizontal-wire antenna, 349 ff; characteristic impedance of, 351; current in, 351; description of, 349, 350; diagram of, 350; directional arrays of, 353, 356, 357; effective length of, 352; far field of, 352, 353, graphs of, 354–6; parameters for, table of, 353; wave number of current in, 351
- Houdzoumis, V., 330
- hybrid junction, for use with loop probes, 516, 517, 530
- impedance, of antennas and arrays. *See* under name of antenna or array

- apparent load, 481; measurement of, 492 ff
- characteristic, of transmission line, general, 477;
lossless, 490
- driving-point, 2, 17
- internal, per unit length, 304; of conducting
cylinder, 426
- of load, terminating line, 480, 481
- measurement of, 702–10
- per unit length, 477; of uniform line, 479
- phase-sequence, 95, 106, 110
- self- and mutual, calculation by EMF method,
16–20, 126; of circular array, 94, 95;
comparison of sinusoidal and two-term
theories, 126, 127; measurement of, 502–8; of
two-element array, 65, 73
- surface, of lossy ground plane, 437
- of transmission line, lossless, 492; lossy, 490; at
SWR maxima or minima, 491
- impedance matrix, 112; in curtain array, symmetry
properties of, 112, 121, 122, 133, 134
- integral equation, approximate, 22, 23, 452 ff;
numerical results with, graph of, 458, tables
of, 459
 - for center-driven dipole, 20–3
 - for current on infinite antenna, 465 ff
 - exact, 22, 452 ff; numerical results with, graph of,
458, table of, 459
 - in matrix notation, 107–11
 - numerical methods for solving, 23–30, 452 ff
 - for sequence currents of circular arrays, 56, 83;
properties of, 57–9; solution of, 59–62, 84–6
 - for single receiving antenna, 51; solution of, 52
 - for single transmitting antenna, 33, 36; properties
of, 33–5; solution of, 36–41
 - See also* integral equations, simultaneous
- integral equations, simultaneous, for arrays with
unequal elements, 160, 211; solution of, 160–2
 - for circular array, 81, 82; in matrix notation, 107,
108; reduction to single equation, 83, 107
 - for curtain array, 114, 115; solution of, 114 ff
 - for general array, 379 ff
 - for planar and three-dimensional arrays, 241–5;
solution of, 245 ff
 - for two-element array, 54, 55; reduction to single
equation, 56
- integrals, generalized sine and cosine, 17, 40
- kernel, of integral equation, approximate, 23, 452; for
center-driven dipole, 22, 23; for circular array,
420–4; difference, 55, 82, 380; exact, 22, 452;
improved, 421, 422; modified, 393, 394, 397,
421; refined, 408, 422; self- and mutual
interaction, 380, 421
- King, R. W. P., xvii, xviii, 156, 157, 159, 238, 240,
291, 293, 295, 309, 310, 316–29, 332–42, 350,
353–6, 358, 361, 364, 375, 579
- King–Middleton second-order values of admittance,
49; graph of, 50
- King–Sandler theory for curtain arrays, 114 ff, 156,
157, 159
- large circular array, of lossless elements, analysis of,
396 ff
 - basic properties of, graphs of, 392–4
 - conditions for, 395
 - currents in elements of, 396
 - diagram of, 393
 - effect of ohmic losses in. *See* large circular array,
of lossy elements
 - end correction for current, 408, 409
 - historical background of, 392–4
 - modified kernels for, 393, 394, 397, 421;
asymptotic formulas for, 398; imaginary
part of, table of, 402; properties of, 398;
refined real part of self-term, 408, 422
 - numerical methods applied to, 464, 465
 - phase-sequence admittance of, 398
 - phase-sequence coefficients of, 396; behavior
near resonance, 403, 404; parameters in,
397, 399, 402, 403, graph of, 399
 - phase-sequence resonances in, properties of, 395,
399 ff
 - quality factor of resonance in, 404
 - radiation field of, near resonance, 405–9; array
factor for, 405–8; element factors for, 405;
properties of, 406, 407, graphs of, 401, 402
 - resonant spacings for, 400–3, 407; table of, 402
 - self- and mutual admittances of, 398, 400; graph
of, 401; table of, 402
 - two-term theory for, 396 ff; refinements for
numerical calculations, 408, 409
 - vertical directivity of, 407
 - See also* resonant array with two driven elements
- of lossy elements, 425 ff; array factor for *n*th phase
sequence, 436
 - current on elements of, 448
 - driving-point admittance of, 430, 433–5; graphs
of, 433, 434, 443–6; tables of, 435, 442, 447
 - effect of lossy ground plane, 425, 436–47
 - effective conductivity of monopoles in, 440, 441;
table of, 441
 - end-corrected current distribution, 448
 - equivalent circuit for, derivation of, 431–3; graph
of, 432
 - field pattern of, 435, 436
 - formulas for computer implementation, 446–51
 - integrals equations for, 427–9
 - kernel, of integral equations, parts of, 450, 451
 - loss parameters for, 450
 - measurement of sharp resonances in, 534–8;
comparison with theory, 442–7;
experimental model for, 535–8
 - phase-sequence admittances of, 451

phase-sequence coefficients of, 449; parameters in, 449, 450
qualitative behavior of, 430–3; for fixed- m/N array, 432, 433; for fixed- N array, 431, 432
quality factor for, 431
radiation resistance, of m th phase sequence, 431
resistance due to ohmic losses, 431
resonant frequencies for, 435, 441, 442, 447
self- and mutual admittances of, 451
surface currents on lossy ground plane, 437–9
time-average power, on lossy ground plane, 437–41, table of, 441; on monopoles, 440, table of, 441
two-term theory for, 429, 430, 446–51
length, complex effective, 53
log-periodic array, active and inactive elements in, 225 ff
admittance, of elements in, 221–3, 228, 230–5; input, of array, 221, graph of, 237
analysis of, 216–21
beam width of, graph of, 239
characteristics of 12-element array, 222 ff; frequency-independent, 228 ff
currents, along elements of, 225, 227; graphs of, 226, 232
description of, 215, 216
diagram of, 216, 217
driving-point admittances of, 222 ff; graphs of, 223, 230, 233, 234
driving-point currents, in elements of, 221, 223, 231, 233; graphs of, 224, 231
field patterns of, 227, 228, 238
frequency-independent properties of, 228 ff; useful range of, 235
frequency periodicities in, 215, 216
parameters of, 215
relative power distributions in, 225, 227, 235, 236
side lobes in field of, 238, 239
voltages driving elements in, 221, 233; graphs of, 224, 231
loop, bridged, 528
dipole-mode currents in, 508, 509, 514, 515; tests for, 515–17, 529
doubly-loaded, analysis of, 516, 517; diagrams of, 512, 528; properties of, 519–24, 526
as probe, 511 ff; error ratios of, 517–20, 522, 524; sensitivity constants of, 514–21, 523; *see also* probe
singly-loaded, analysis of, 515, 516; diagrams of, 512, 528; properties of, 520–5
small, circular, 517–20, 523, 524; square, 511–22, 525, 526
transmission-line mode currents in, 508, 514, 515
Lorentz condition, 4, 9
Mack, R. B., xviii, 19, 43, 44, 74, 102, 122, 180, 183
magnetic field, definition of, 3

even and odd parts of, 513
far-zone, 9, 10
of finite cylindrical conductor, 9
of infinitely thin antenna with sinusoidal current, 15
measurement of, 511 ff; in presence of elliptically polarized electric field, 531–4
near-zone, of electrically short antenna, 12
of vertical dipole over earth or sea, 292–303
magnetic vector, 3
Mailloux, R. J., xviii, 154–9
matrix notation, for circular array, 103–11; for general array, 384, 385, 390, 391
Maxwell's equations, 3; boundary conditions for, 3, 4
measurement, of fields, 508–34
of impedances, 492–508; difficulties in, 504
methods of. *See* measurement methods
of sharp resonances, 534–8
measurement methods, 475 ff; directional-coupler method, 493, 496, 497; distribution-curve method, 493–5, 497–9; multiple-probe method, 493–6, 534; open circuit–short circuit method, 506–8; resonance-curve method, 493–5, 499–502
method of moments, 24, 453, 462; *see also* Galerkin's method with pulse functions
microstrip, horizontal dipoles on, 372–5; patch antennas on, 375–8; transmission lines on, 376; vertical dipoles on, 325, 338–42
microstrip patch antenna, 375–8; diagram of, 375; radiation field of, 376–8
monopole, as electric-field probe, 509–11; relative sensitivity of, graph of, 511
as end-load on coaxial line, 484, 485
grounded, 303–8; driving-point impedance of, 304–7; *see also* arrays with horizontal and vertical elements
terminal-zone correction for, 49, 89, 93, 484, 485
See also cylindrical antenna
Morita, T., 18, 20
Morris, I. L., xviii, 173, 182, 190
multiple probe, measurement method, 493–6, 534
mutual admittance. *See* admittance, self- and mutual, *also* under name of array
mutual impedance. *See* impedance, self- and mutual, *also* under name of array
Norton surface wave, 291
numerical methods, applied to integral equations, for array of cylindrical dipoles, 463, 464
for general array, 385–90; notation for, 379–85
for infinite antenna, 456, 469 ff
for isolated antenna, 23–30, 452 ff; improvements for, 461, 462; numerical results of, 458–60; roundoff errors in, 461
for resonant circular array, 464, 465

- open circuit–short circuit, measurement method, 506–8
- parallel non-staggered array. *See* curtain array
- parasitic array, with elements of equal length, 153 ff;
admittance of, 156; current in each element of, 154, graphs of, 155, 157, 158; diagram of, 154; field pattern of, 154, graph of, 159; programming aspects of, 386, 387
with elements of unequal length, 160 ff; integral equation for parasitic element, 160, 161; two-element example of, 179–87, computer printout of properties of, 184, 185
three-term theory for, 160–9; with half-wave elements, 170–3
two-term theory for, 153–9
See also parasitic array with two equal elements; parasitic array with 20 equal elements
- parasitic array with two equal elements, admittances of, 76; currents in, 66, 67, 73, 74, 179 ff, graphs of, 75, 181, 183; field patterns of, 182; with tuned parasite, 67, 74, 75; with untuned parasite, 66, 73, 75
- parasitic array with 20 equal elements, 154 ff;
admittances of, graph of, 156
currents, at centers of all elements, graphs of, 157, 158; on driven element, graph of, 155; on typical parasitic element, graph of, 157
field patterns of, 159
See also Yagi–Uda array
- phase sequence, of circular array, 79, 83;
transformation matrices for, 105, 106; of two-element array, 56
- planar array, general, analysis of, 241 ff; currents in elements of, 244, 247–9; evaluation of coefficients for, 249 ff; field pattern of, 253–5; five-term theory for, 247–9; full-wave elements, broadside, 263–6, 268, endfire, 264–8; half-wave elements, broadside, 266, 268–70; integral equations for, 245–7
- nine-element broadside, full-wave elements in, 262 ff; admittances of, table of, 265; coefficients for currents in, 265; currents in, graph of, 266; description of, 263; field patterns of, graphs of, 268; impedances of, table of, 265
half-wave elements in, 266 ff; admittances of, table of, 269; coefficients for currents in, 269; currents in, graphs of, 269; field patterns of, graphs of, 270; impedances of, table of, 269
- nine-element endfire, full-wave elements in, 264 ff; admittances of, table of, 265; coefficients for currents in, 265; currents in, graphs of, 267; description of, 264, 266; field patterns of, graphs of, 268; impedances of, table of, 265
- nine-element parasitic, 270 ff; admittances of, table of, 271; coefficients for currents in, 271;
currents in, graph of, 271; impedances of, table of, 271
two-element collinear or staggered, 256–63;
admittances of, 257, 258; currents in, 259, 261–3; diagrams of, 256; impedances of, 258–60
- potential, scalar. *See* scalar potential
vector. *See* vector potential
- potentials, field in terms of, 4; integral forms of, 5
- power, in antenna with sinusoidal current, 15
in couplet, 76
input, to section of transmission line, 492
in log-periodic array, 225, 227, 235, 236
in three-element array, 127
time-average, across closed surface, 5, 6, 12, 15, 18; on surface of lossy ground plane, 437
- power pattern, definition of, 12, 13; for electrically short antenna, 12
- Poynting vector, 5
- probe, characteristics of, for small loops, table of, 520; construction of, 520, 525–9; for measuring charge or electric field, 509–11; for measuring current or magnetic field, 511–26; tests of probe coupling, 502
- programming considerations, for general array, 385 ff; matrix elements in, 384, 385; parameters in, 385; special cases in, 386–91
- propagation constant, of transmission line, 477; of uniform line, 479, 487
- pseudopotential, Fermi, definition of, 392
- pulse functions, 24, 455; graph of, 25
- radiation pattern. *See* field factor; field pattern, *also* under name of antenna or array
- radiation resistance, 15, 17, 311
- Rao, B. R., 353
- reactance. *See* impedance
- receiving antenna, 50 ff; boundary conditions for, 51; complex effective length of, 53; current distribution on, 52; current in load of, 52, 53; integral equation for current in, 51
- receiving array, discussion of, 198, 205–8; effective length of, 208
- reciprocal theorem, applied to receiving array, 206–8
- reflection coefficient, of load, 488; measurement of, 493–7; plane-wave, 290, for layered surface, 299; in terms of terminal functions, 490
- regions 0, 2 for two-layered region, 290; diagram of, 291
- regions 0, 1, 2 for three-layered region, 292, 343; diagrams of, 293, 344
- resistance. *See* impedance
- resonance curve, measurement method, 493–5, 499–502
- resonant array with two driven elements, 409 ff; array factor for, 412
choice of parameters for, discussion of, 412–15

- conditions for traveling-wave distribution of current in, 411
 - current in elements of, 410
 - driving-point admittances of, 411; frequency dependence of, 413, graphs of, 414
 - over earth or sea, 416–20
 - far field of, for array over earth or sea, 419, 420; graph of, 419
 - for array in free space, 415–17; graphs of, 416, 417
 - kernels, in integral equation for, types of, 420–4
 - phase-sequence resonances of, 413; table of, 415
 - resonant frequencies, predicted, 413–15; table of, 415
 - self- and mutual admittances of, 410
 - total power supplied to, 411
 - vertical directivity of, 414; table of, 415
- Sandler, B. H., 579
- Sandler, S. S., xviii, 156, 157, 159, 291, 293, 316–29, 332–42, 579
- scalar potential, 4, 5, 8, 21
- scalar potential difference (or voltage), between conductors of transmission line, 477, 478; for uniform sections of lines, 479, 480, 487
- scanned array, 128 ff; beam pointing error of, 131, 135, graph of, 136; driving-point impedance of, graph of, 134; field properties of, 135–7
- scanning, with three-dimensional array, 284 ff
- Schelkunoff, S. A., xvii
- self-admittance. *See* admittance, self- and mutual, *also* under name of array
- self-impedance. *See* impedance, self- and mutual, *also* under name of array
- sensitivity constant, of circular loops, 518, 519; graph of, 523; table of, 520
- of short dipole, 509
 - of short monopole, graph of, 511
 - of square loops, 514–18; graph of, 521; table of, 520
- sequence admittances, in small circular loop, 519
- short antenna, admittance of, 41; current in, 41; directivity of, 13; field of, 11–13, graph of, 12; as probe, sensitivity of, 510, graph of, 511
- skin depth, definition of, 426
- Southworth, G. C., xvii
- standing wave, along transmission line, lossless, 491; uniform, 488
- standing wave ratio, 491; measurement of, 494, 497–502; relation to curve width, 498
- Starnecki, B., xvii
- Sterba, E. J., xvii
- Storer, J. E., 519
- Stratton, J., xviii
- surface distributions, of current and charge, measurements of, 530
- surface wave, array for generating, 409 ff
- susceptance, correction for, three-term theory, 42; two-term theory, 49, 50, 89; *see also* admittance
- symmetrical components, method of, 54–7, 79–80, 83, 103–7
- Tai, C. T., xvii
- Taylor, T. T., xvii
- terminal functions, 490; obtained from measurements, 498–501
- terminal zone, 476 ff; correcting susceptance for, 42, 49, 89, 481; extent of, 478, 479; *see also* terminal-zone network
- terminal-zone network, 481 ff; diagrams of, 480, 483; examples of, 482–6; lumped elements in, 479–82
- terminated insulated antenna, in earth or sea, 357 ff; characteristic impedance of, 357; diagram of, 358; directive arrays of, 358, 359; driving-point impedance of, 357; effective length of, 358; electromagnetic far field of, 358, 359; wave number of current in, 357
- testing functions, 25
- three-dimensional array, analysis of, 241 ff; excitation of, 288, 289; field pattern of, 253–5; integral equations for, 241–7; scanning with, 284 ff; *see also* three-dimensional array of 27 elements
- three-dimensional array of 27 elements, diagram of, 273
 - with driving-point currents specified, 279 ff
 - with driving voltages specified, 272 ff
- field patterns of, 281, 283–8; graphs of, 284, 285
- with full-wave elements, 272 ff; currents in, 272, 286, 288, graphs of, 276, 277; relative power in, 272, 288; tables of properties of, 274, 287
- with half-wave elements, 272 ff; currents in, 277–9, 281, graphs of, 278, 279, 282, 283; relative power in, 273, 279, 281, graph of, 283; tables of properties of, 275, 280
- three-element array. *See* curtain array of three elements; Yagi–Uda array, three-element
- three-term theory, for isolated cylindrical antenna, 36–41
 - in matrix notation, for *N*-element circular array, 107–10
 - modified, for array with parasitic elements of unequal length, 160 ff; for driven array with elements that differ greatly in length, 208 ff
 - for two-element array, 59–69
- transmission line, admittance per unit length of, 477, 479; apparent load terminating, 480, 481; characteristic impedance of, 477; coupling coefficients for, 477, 478; current and voltage distributions in, 487 ff; impedance per unit length of, 477, 479; input power to, 492; lossless, 490–2; lumped elements for terminal

- zone, 479–82; measurement procedures for, 475, 476, 492 ff; propagation constant of, 477, 479; reflection coefficient for, 488–91; resonant, 500; standing wave ratio of, 491; terminal functions for, 490; terminal zone of, 476 ff; uniform sections of, 475, 479, 487–92; useful properties of a quarter-wave section of, 492
 - transmission-line end effects, for change in line spacing, 485, 486; for dipole and two-wire line, 482, 483; for monopole over ground plane, 484, 485
 - transmission-line equations, generalized, 477; solutions for voltage and current, 487–90; for uniform sections of lines, 479, 490
 - transmission-line measurements, apparent terminal admittances and impedances, 499; balancing for, 502; directional-coupler method, 493, 496, 497; distribution-curve method, 493–5, 497–9; multiple-probe method, 493–6, 534; probe coupling in, 502; resonance-curve method, 493–5, 499–502
 - transmission-line mode, 508, 513–15; in small loop, 515, 516
 - two-element array. *See* arrays with two staggered elements; collinear array, two-element; curtain array of two elements; parasitic array with two equal elements
 - two-term theory, for circular array, 84–6, 111; for curtain array, 114 ff; for cylindrical antenna, 48–50; for general array, 398 ff; for two-element array, 70–8; for Yagi–Uda array, 153 ff
 - two-wire line, test for balance, 502
 - uniform array, array factor of, 124
 - vector, electric. *See* electric vector
magnetic. *See* magnetic vector
 - vector potential, for center-driven tubular dipole, 21, 22, 33; for electrically short antenna, 12; even and odd symmetry in, 243, 244; for infinitely thin antenna, 8; on k th element of curtain array, 114, of planar array, 244; for perfect conductor, 4, 5; for unloaded receiving antenna, 51
 - vector potential difference, between conductors of transmission line, 477, 478; on elements of unequal length, 161, 162, 209, 210; on k th element of circular array, 82, of curtain array, 115, of planar array, 245–7; for two parallel antennas, 54, 55; for uniform sections of lines, 480
 - vector potential integral, variation with current, 33–5
 - vertical antennas, on the earth, with ground networks, 303–10; with top-loading panels, 311, 312; VLF examples of, 312–14
 - over the earth, electric far field of, 314, 315, graphs of, 316–29, 332–42; high-frequency example of, 319
 - vertical dipole, over planar earth or sea, 290 ff; conventional theory of, 290, 291
 - diagram of, 291
 - with dielectric layer, 292, 321, 323–5; diagram of, 293; examples of, 323–5; far field of, graphs of, 332–42
 - electromagnetic field of, 292 ff; conditions for, 292; in cylindrical coordinates, 293; when dipole is on boundary, 294–6, 302, 303; in spherical coordinates, for far field, 301, 302, for intermediate field, 296, 297
 - far field of, 298 ff; conditions for, 300; formulas for, 299–303
 - over spherical earth or sea, 327 ff; comparison with planar-earth results, 336, 337; electromagnetic field of, 327, 328; examples of, 333–41; parameters for, 329–33, table of, 330, 331
 - See also* vertical antennas
 - voltages, driving-point, for N -element circular array, 83, 86; relation to sequence voltages, 56, 57, 86; for two-element array, 56, 57; for uni-directional couplet, 67, 76
 - sequence, in circular array, 87; relation to arbitrary driving voltages, 64, 87; in two-element array, 56, 57
- Walkinshaw, W., xvii
- wave equation, for vector potential, for receiving antenna, 51; for transmitting antenna, 33
- wave number, in air half-space (region 0), 290; in dielectric layer (region 1), 292; in earth or sea half-space (region 2), 290; free-space, 4
- waves, lateral, 291, 300, 303, 307, 315, 349; trapped, 294
- Whinnery, J. R., xvii
- Whiteside, H., 511, 525, 526
- Wu, T. T., xviii, 392, 393
- Yagi–Uda array, 162 ff; analysis of, 160–79
 - coefficients for, 164–7; with half-wave parasitic elements, 170, 171
 - conductance of, 177
 - contour diagrams of properties of, 190, 192, 193
 - diagram of, 163
 - directivity of, 177–9
 - element currents in, 162, 163; with half-wave parasitic elements, 172
 - evaluation of Ψ functions for, 167–9
 - far field of, 173–6
 - field factor of, 174–6
 - front-to-back ratio of, 176; graphs of, 189, 190, 192, 197

- gain of, 178, 179; graphs of, 190, 192, 197
- with half-wave parasitic elements in, 170 ff;
 - calculation of Ψ functions for, 171, 172
- input impedance of, graphs of, 190, 193, 198
- integral equation, for driven element, 163; for parasitic elements, 163
- ten-element. *See* Yagi–Uda array, with 8 directors
- three-element, 182, 187–90; currents in, 188; field pattern of, 188; forward gain of, 190; front-to-back ratio of, 189, 190; input impedance of, 190; *see also* Yagi–Uda array, with 1 director
- three-term theory for, 162 ff
- with 1 director, 191 ff; field pattern of, 194; forward gain of, 197; front-to-back ratio of, 197; input impedance of, 198; phasor diagrams of currents in, 195
 - with 2 directors, 191 ff; field pattern of, 194; forward gain of, 197; front-to-back ratio of, 197; input impedance of, 198; phasor diagrams of currents in, 195
 - with 4 directors, 191 ff; field pattern of, 194; forward gain of, 192, 197; front-to-back ratio of, 192, 197; input impedance of, 193, 198; phasor diagrams of currents in, 196
 - with 8 directors, 196 ff; coefficients for currents in, 199; computer printout for, 199–203; currents in elements of, 200–2, graphs of, 204, 205; dimensions of array, 199; field pattern of, 203, graph of, 206; front-to-back ratio of, 197, 203; forward gain of, 197, 203; input admittance and impedance of, 198, 203
- Yagi–Uda receiving array, 198, 205–8; current in load, 207; effective length of, 208