

# Index

- Accuracy
  - Location, 390–1, 405–6
  - Ranging, 398ff
- Adaptive sidelobe canceller, 67
- Alamouti scheme, 100
- Angular spread, 376, 379
- Antenna
  - Antipodal, 155, 157, 158
  - Aperture, 42
  - Balanced, 43
  - Bandwidth, 41
  - Bicone, 164, 286, 299–302, 320–1, 426
  - Bowtie, 45–6, 167
  - Diamond dipole, 176
  - Dipole, 42–45, 111, 442
  - Directivity, 41
  - Disc monopole, 120
  - Discone, 149
  - Elliptical dipole, 171
  - Effective area, 38
  - Efficiency, 425–8, 441
  - Four-square, 233
  - Frequency-independent, 45–6, 111, 288
  - Horn, 147–8, 443, 428, 444, 462
  - Horn-shaped self-complementary, 333–57
  - Hybrid, 442–3
  - Impedance, *see* Impedance
  - Impulse radiating, 466–8
  - Key to, 27
  - Log periodic, 387, 461
  - Matching, *see* Matching
  - Monopole, 44–5, 112
  - Omni-directional, 116, 153
  - Patch, 70, 444
  - Planar inverted cone, 333–57
  - Polarisation, 460
  - Printed, 3, 45, 150, 333, 336
  - Reflector, 148, 453, 454–63
  - Resistive loading, 425, 441
  - Roll, 148, 153
  - Self-complementary, 333
  - Slot, 132, 429
  - Spiral, 48, 234, 429, 461–2
  - Vivaldi, 155, 429
  - Wideband, 45, 234
  - Wire, 42
- Antenna array, 49ff, 69ff, 221, 389ff, 433ff, 448
- Array
  - Active, 108, 235
  - Adaptive, 74
  - Beamforming, *see* Beamforming
  - Broadside, 53, 221
  - Circular, 395
  - Efficiency, 454, 460–1, 466
  - End-fire, 53, 221, 391–2
  - Factor, 56ff, 238
  - Gain, 65
  - Linear, *see* Linear arrays
  - Orientation, 379
  - Passive, 108, 235
  - Pattern multiplication, 55, 223
  - Phased, 230
  - Scanning, 224
  - Series fed, 236
- AWGN channel, 89

- BAN, *see* Wireless body area network  
Beam steering, 78  
Beamforming, 75ff, 241, 394, 398  
BEAMLOC, 401  
Bloss network, 238  
Body area network, *see* Wireless body area network  
Broadside array, *see* Array  
Butler matrix, 238
- Capacity, 364–70, 375–6  
Central limit theorem, 92  
Channel impulse response, 268, 310–13, 319–24, 336  
Channel model,  
  Delta-K, 317, 325  
  Saleh-Valenzuela, 310–19, 325–7  
  Single-Poisson, 318, 321  
  Split-Poisson, 319, 321  
  Two-Cluster Poisson, 319, 321  
Channel state information at receiver, 93, 102, 362, 365–74, 377, 381  
Channel state information at transmitter, 362, 366–75, 378, 380–1  
Chi-square distribution, 92  
CIR, *see* Channel impulse response  
Circular array, 63, 71  
Circular polarisation, *see* Polarisation  
CLEAN algorithm, 312  
Coaxial transition, 428, 443  
Coexistence, 221  
Combining, *see* Diversity  
Conductivity, 26  
Conformal array, 72  
Consumer applications, 197  
Correlation, 310, 323–4, 364, 367, 375–80  
Coverage range, 371, 375, 381  
CPW, *see* Waveguide  
CSIR, *see* Channel state information at receiver  
CSIT, *see* Channel state information at transmitter  
Curl, 26
- Delay-line, 109, 242  
Delay spread, 204, 241  
Delta-K model, *see* Channel model  
Dielectric  
  Constant, 392, 426, 439–40  
  Properties of materials, 392, 423, 439, 445  
  Loading, 428–9, 462
- Digital versatile disk, 208  
Dipole, *see* Antennas  
Direct-sequence code division multiple access, 2, 6, 8–9, 14, 107, 214  
Directive gain, 41  
Directivity, 41–43, 45, 224, 340, 345, 457, 466  
Divergence, 26  
Diversity  
  Receive, 93  
  Combining, 95  
  Transmit, 100  
  MIMO, 102  
Dolph-Tschebyscheff distribution, 59ff  
DS-CDMA, *see* Direct-sequence code division multiple access
- E-plane, 123, 124  
Edge ray, 457  
Effective area, 39  
Effective isotropic radiated power, 107  
Effective length, 38, 46  
EIRP, *see* Effective isotropic radiated power  
Eigenspectrum, 377–8  
Electric field intensity, 26  
Electric flux density, 26  
Electric scalar potential, 28  
Electrodynamics, 25  
End-fire array, *see* Array  
Equal gain combining, 98  
Equalisation, 241  
Equivalent circuit, 37–8
- Fading, *see* Fast fading *and* Shadowing  
Far field, 22, 30, 33–6, 39, 45, 287, 306, 343  
Fast fading, 91, 268  
FCC, *see* Federal Communications Commission  
FDTD, *see* Finite-difference time-domain  
Federal Communications Commission, 2–3, 12, 107, 197, 154, 266  
Feed, 125, 459  
Fidelity, 151  
Filters  
  Band pass, 453  
  Matched, 392, 402–5, 424  
  Pre-filtering, 399  
First null beamwidth, 40–1  
Finite-difference time-domain, 164, 197, 199, 296–7, 322, 346–53, 356  
Finite length dipole, *see* Antennas

- FNBW, *see* First null beamwidth
- Fractional bandwidth, 67
- Fraunhofer region, *see* Far field
- Free-space pathloss model, *see* Pathloss model
- Fresnel region, 33, 395, 410, 419
- Frequency hopping, 10
- Frequency regulations, 12
- Friis' transmission formula, 30, 39, 283–5, 287
- Full-wave, 234
  
- Gamma distribution, 92
- Gaussian pulse, 27, 285, 288, 322–3, 349, 405, 458
- Geolocation systems, 5
- GPR, *see* Ground probing radar
- Grating lobes, 83, 231, 246
- Green's functions, 234
- Ground probing radar, 419, 424, 430, 432, 440
- Group delay, 160
  
- H-plane, 123, 124
- Half power beamwidth, 40–1
- Harmonic representation, 29
- Harmonics, 116
- HDR, *see* High data rate
- Helmholtz equations, 29, 421
- Hertzian dipole, 31, 35, 42, 69
- High data rate, 2, 9, 14–15, 93–4, 309, 324, 364, 367
- Horn-shaped self-complementary antenna, *see* Antennas
- HPBW, *see* Half power beamwidth
- HSCA, *see* Horn-shaped self-complementary antenna
- Huygens' principle, 42
  
- IEEE 802.15.3a, *see* IEEE 802.15 models
- IEEE 802.15.4a, *see* IEEE 802.15 models
- IEEE 802.15 models, 2–3, 14, 303ff, 324ff, 325ff, 353
- Imaging
  - Breast cancer, 438
  - High resolution, 418–9
- Impedance, 30, 37–8, 41, 45, 332–4
- Impulse radio, 2–3, 6–9, 14, 23, 147, 265, 284, 332, 339
- Impulse response, 204
- Interference, 392, 400, 405
- Intrinsic impedance, 32
  
- IR, *see* Impulse radio
- Isotropic, 221
  
- Large-scale fading, *see* Pathloss
- Laplace operator, 29
- LDR, *see* Low data rate
- Linear arrays, 56, 58, 70, 221
- Linear polarisation, *see* Polarisation
- Line-of-sight, 34, 269, 279, 285–6, 292–3, 298–306, 322–26, 340
- Location systems, *see* Geolocation systems
- Lorentz gauge, 28
- LOS, *see* Line-of-sight
- Lossy media, 426
- Low data rate, 309, 325
  
- Magnetic field intensity, 26
- Magnetic vector potential, 28
- MAI, *see* Multiple-access interference
- Mainlobe, 40–3
- Marcum Q function, *see* Q function
- Matching, 38–9, 287, 333–4
- Material characteristics, *see* Materials
- Materials
  - Cinder block, 262, 270–1, 273, 280
  - Double glazing, 262, 270–1, 273, 280
  - Fibreboard, 262, 270–1, 273, 280
  - Glass, 262, 270–1, 273, 280
  - Melamine chipboard, 262, 270–1, 273, 280
  - Metal, 262, 270–1, 273, 280
  - Plasterboard, 262, 270–1, 273, 280
  - Plywood, 262, 270–1, 273, 280
  - Red brick, 262, 270–1, 273, 280
  - Softwood, 262, 270–1, 273, 280
  - Venetian blind, 262, 270–1, 273, 280
- Maximal-ratio combining, 96
- Maxwell's equations, 25–32, 37, 267, 284, 286, 291, 296
- MB-OFDM, *see* Multiband OFDM
- Medium-scale fading, *see* Shadowing
- Measurements
  - On-body, 335
  - MIMO, 367
- Method of moments, 234
- Microstrip, 236
- MIMO, *see* Multiple-input multiple-output
- MISO, *see* Multiple-input single-output
- Monopole, *see* Antennas
- Multiband OFDM, 14, 107

- Multipath, 90, 390–1, 394, 405
- Multipath fading, 321–2, 379
- Multiple-access interference, 2, 6, 10
- Multiple-input multiple-output, 3, 23, 361–81
- Multiple-input single-output, 362–374
- Mutual coupling, 65, 74, 234
  
- Nakagami-*m* channel, 92, 313, 327, 380
- Near field, *see* Fresnel region
- Network analyser, *see* Vector network analyser
- NLOS, *see* Non-line-of-sight
- Noise temperature, 459–60
- Non-centrality parameter, 92
- Non-line-of-sight, 269, 298–306, 320–1, 324–6, 345
- Null, 225, 248
- Null steering, 81
  
- OBS, *see* Obstructed line of sight
- Obstructed line of sight, 269
- OFDM, *see* Orthogonal frequency division modulation
- Orthogonal frequency division modulation, 2, 6, 9–11, 14–17, 22, 214, 381
- On-body channel measurements, 322–357
- Outage, 89
  
- PAN, *see* Wireless personal area network
- Pathloss model, 267, 284ff
  - deterministic, 262, 267, 284ff, 332, 346
  - breakpoint, 291–6, 299, 342–3
  - dual-slope, 293–6, 342–3
  - empirical, 297ff
  - free-space,
    - IEEE standard models, 304–5
    - WBAN, 341, 348ff
- PCB, *see* Printed circuit board
- PDP, *see* Power delay profile
- Permittivity, 26
- Perfectly matched layer, 200
- Personal area network, *see* Wireless personal area network
- Phase centre, 50, 387, 424, 428–9, 451, 454, 459–62, 466–8
- PICA, *see* Antennas
- Planar array, 62, 72, 72
- Planar inverted cone antenna, *see* Antennas
- Plane wave, 33, 395, 406
  
- PML, *see* Perfectly matched layer
- Poisson process, 312, 317–21, 326
- Polarisation, 33–35, 270, 392, 421, 429, 444, 454, 458, 461
- Power delay profile, 313, 317, 326, 345
- Power density, 35–9
- Power gain, 41–2
- Printed antenna, *see* Antennas
- Printed circuit board, 178
- Propagation model, *see* Pathloss model
- Pulse position modulation (PPM), 7
  
- Q-function, 93
  
- Radar, 2–3, 11, 452, *see also* Ground probing radar
- Radiated power, 36
- Radiation efficiency, 41–2
- Radiation intensity, 39–42
- Radiation resistance, 37, 43, 45
- Radiation pattern, 39, 169, 397
  - Directivity, *see* Antenna
  - Half-power beamwidth, 41, 69, 71, 86
  - Mainlobe, 40, 71
  - Null, 40, 41
  - Sidelobe, 40, 71, 86, 398
- Radio astronomy, 459
- Rake receiver, 3, 5, 7–8, 91, 319–23, 354
- Ray-tracing, 216, 262, 296, 346–7, 456
- Rayleigh fading, 92, 325
- Rayleigh pulse, 156
- Rectangular arrays, 62
- Reflection coefficient, 66, 404
- Resonance, 115
- Retarded potentials, 29
- Return loss, 115
- Rice distribution, 92
- RMS delay spread, 311, 314–17, 324–6, 345–6
- Rumney's principle, 45
  
- S parameters, *see* Scattering parameters
- Saleh-Valenzuela model, *see* Channel Model
- Scattering parameters, 179, 182
- Selection combining, 99
- Shadowing, 268, 301–3, 304–5, 345
- Shannon capacity, *see* Capacity
- Sidelobe, 40
- SIMO, *see* Single-input multiple-output

- Single-input multiple-output, 362–74
- Single-input single-output, 362–4, 368–74
- Single-Poisson channel model, *see* Channel model
- SISO, *see* Single-input single-output
- Small-scale channel modelling, *see* Channel model
- Small-scale fading, *see* Channel model
- Smart antennas, *see* Array
- Smith's chart, 114
- Spatial channel modelling, 361–81
- Spatial correlation, 375ff
- Spatial filtering, 73
- Spatio-temporal, 197, 201
- Split-Poisson channel model, *see* Channel model
- Standardisation, 2, 13–16, 262, 306
- Standing waves, 121
- Steering vector, 75
- Substrate, 112
- System level modelling, 332, 353–4
  
- Tapped delay line, 242
- Taylor distribution, 62
- TDL, *see* Tapped delay line
- TEM, *see* Transverse electromagnetic
- TH, *see* Time-hopping
- Time-hopping, 2, 6–10
- Transfer function, 150, 202, 454
- Transmission lines, 30
- Transmit-MRC, 100
- Transverse electromagnetic, 147
  
- Travelling wave, 121, 425, 428
- Two-Cluster Poisson channel model, *see* Channel model
  
- UCA, *see* Circular array
- ULA, *see* Uniform array
- Ultra-wideband, 1ff
- Uniform array, 56, 70, 379
- Uniform circular array, *see* Circular array
- Uniform linear array, *see* Uniform array
- UWB, *see* Ultra-wideband
- UWB Forum, 2, 9, 14
  
- Vector network analyzer, 121, 337, 342, 364
- VNA, *see* Vector network analyser
- Voltage standing wave ratio, 462, 465
- VSWR, *see* Voltage standing wave ratio
  
- Wave equation, 29
- Waveguide
  - Coplanar, 112
  - Dual ridged, 452, 463–6
- WBAN, *see* Wireless body area network
- WLAN, *see* Wireless local area network
- Weight vector, 75, 78
- Window functions, 85
- Wireless body area network 14, 262, 306, 325, 331ff, 356
- Wireless local area network, 197
- Wireless personal area network, 197, 281, 303, 324

