

Index

A

- American Digital Cellular and Japanese Digital Cellular systems, 138
- Amount of fading (AF)
 - cascaded fading channels, 233, 235
 - Gaussian pdf, 366
 - lognormal shadowing channel, 364, 366
 - MRC diversity, 362
 - Nakagami fading, 211
 - Nakagami parameter, 364, 366
 - Rayleigh fading, 200–201
 - Rician fading, 203, 204
 - shadowing models, 216
 - short term faded Nakagami channel, 362
 - SSC, 363
 - two channel selection combining
 - diversity, 363
- Amplitude shift keying (ASK), 121–122
- Arnold and Strauss's bivariate gamma distribution, 76

B

- Bayes theorem, 86–87
- BER. *See* Bit error rate
- Bessel function, 221, 303
- Beta distribution, 11–13
- Binary phase shift keying (BPSK)
 - digital signal spectra, 127
 - gray encoding, 129, 130
 - M-ary signals, 128–129
 - MQAM, 139–141
 - null-to-null criterion, 127
 - QPSK
 - modulator, 131, 132
 - offset-QPSK scheme, 133, 134
 - phase constellation, 131

- $\pi/4$ -QPSK, 133–136
 - time domain waveforms, 131, 132
 - waveforms, 130
 - signal space, 129
 - symbol error
 - coherent MPSK, 137, 138
 - equivalent bit error rate, 137
 - generic MPSK constellation, 136, 137
 - k bits encoding/mapping, 136
 - spectral efficiencies and SNR, 138, 139
- Binomial distribution, 13–15
- Bit error rate (BER), 255, 256, 307
 - BPSK, 256–259
 - CDF, 259
 - fading channel, 259
 - moderately shadowed channel, 260, 262
 - MRC, 448–450
 - Nakagami channels
 - average error probability, 442, 444, 445
 - hypergeometric function, 443
 - MeijerG function, 443
 - pdf, 449
 - Rayleigh channels, 441–442
 - severely shadowed channel, 260, 261
 - shadowed fading channels
 - average error rates, 446, 447
 - CCI effect, 446
 - cochannels, 448
 - N Nakagami interferers, 445
- BPSK. *See* Binary phase shift keying

C

- Cascaded channels, 306
- Cascaded fading channels
 - AF, 233, 235
 - average SNR, 233

- Cascaded fading channels (*cont.*)
 - CDF, 235, 236
 - density function, 233, 234
 - gamma-distribution, 232
 - MeijerG function, 232–233
 - Nakagami-gamma model, 234
 - Cascaded Nakagami channels
 - AF, 395, 400, 401
 - average error probabilities, 405, 406
 - BER, 401, 402
 - CDFs, 396–401, 404, 405
 - density function, SNR, 395
 - Matlab, 396
 - M-fold convolution, 403, 404
 - MGF, 404, 405
 - MRC diversity, AF, 403–404
 - multihop relayed communication system, 395
 - order statistics, 400
 - outage probability, 401, 403, 405, 407
 - pdfs, SNR, 396, 398–400, 402
 - received signal power, 395
 - threshold SNR, 404
 - Cauchy distribution, 15–16
 - CDFs. *See* Cumulative distribution functions
 - Central limit theorem (CLT), 46–47
 - Characteristic function (CHF), 10–11, 57
 - Chebyshev inequality, 94–95, 323
 - Chi-squared distribution, 16–18
 - Cochannel interference, 5
 - Coherent binary phase shift keying (CBPSK), 367
 - Cumulative distribution functions (CDFs), 8–9, 207–208, 322, 330–331
- D**
- Decision theory and error rates
 - channel noise, 85–86
 - Gaussian case
 - Bayes theorem, 86–87
 - binary channel, 86
 - conditional density functions, 87
 - conditional probability, 87
 - error probability, 87, 89, 90
 - false alarm probability, 89
 - hypothesis testing, 86, 88
 - likelihood ratio, 89
 - probability of miss, 89
 - non-Gaussian case
 - false alarm probability, 91
 - hypothesis testing, 91, 93
 - probability of miss, 91, 92
 - Q function, 92
 - Rayleigh densities, 90
 - Rician densities, 90
- Differential phase shift keying (DPSK), 154
- Digital frequency modulation (DFM)
 - block diagram, 142, 143
 - CPFSK, 144
 - frequency deviation, 143
 - pulse shape, 143
- Diversity techniques, 1
 - AF
 - Gaussian pdf, 366
 - lognormal shadowing channel, 364, 365
 - MRC diversity, 363
 - Nakagami parameter, 364, 366
 - short term faded Nakagami channel, 362
 - SSC, 364
 - two channel selection combining diversity, 363
 - average error probability
 - average error rate, 366–367
 - CBPSK, 367
 - CDF, 369
 - density functions, 373–377
 - dual branch correlated MRC, 372
 - dual branch MRC, 375, 377–379
 - dual branch SC, 371, 372, 378, 379
 - four-branch diversity, 371
 - four channel MRC, 375, 378
 - GSC algorithm, 371, 373
 - hybrid diversity approach, 375
 - Laplace transform, 367
 - MGF, 367–368
 - MRC algorithm, 369
 - Nakagami channel, 368, 373
 - Nakagami-lognormal model, 373
 - Nakagami- m channel, MRC, 370, 371
 - Q function, 368
 - shadowed fading channels, 375, 377, 378, 379
 - branch correlation effects
 - correlated SC and SSC receiver, 337
 - exponential correlation, 334
 - joint CDF, 339
 - Marcum's Q function, 337
 - modified Bessel function, 337, 339
 - MRC algorithm (*see* Maximal ratio combining algorithm)
 - Nakagami parameter, 337, 338
 - pdf, SC algorithm, 339
- cascaded Nakagami channels (*see* Cascaded Nakagami channels)

- CDF, 325
 - diversity receivers, 321
 - EGC algorithm, 324
 - frequency diversity, 318
 - gamma shadowing, 362
 - generalized gamma and Weibull channels
 - AF, 386
 - average error probability, 391, 392
 - BER, dual diversity, 393, 394
 - CDFs, 387–389, 391
 - coherent BPSK modem, 389
 - complementary incomplete
 - gamma function, 390
 - detection scheme, 390
 - dual MRC, 392
 - dual SC, BER, 394
 - “keyhole” scattering, 395
 - MGF, 392
 - modulation type, 389
 - Nakagami- m distribution, 385
 - Nakagami pdf, 385
 - SNR, pdfs, 385, 387, 388, 391
 - GSC algorithm, 361
 - average error probabilities, 408, 409
 - average SNR, 357
 - CDFs, 357–359, 408, 409
 - CDMA system, 353
 - densities and distributions, 359–360
 - gamma random variables, 359
 - joint pdf, 354–356
 - M_c signals, 354
 - Nakagami channels, 358, 360
 - Nakagami- m faded channels, 360, 361
 - normalized peak values, 360
 - outage probabilities, 407, 410
 - output SNR, pdfs, 408
 - RAKE reception, 353
 - Rayleigh channel, 354–356
 - three-branch diversity receiver, pdfs, 358, 359
 - macrodiversity (*see* Macrodiversity techniques)
 - MRC algorithm (*see* Maximal ratio combining algorithm)
 - multipath diversity, 320
 - Nakagami- m distribution (*see* Nakagami- m distribution)
 - noise power, 315
 - outage probability
 - CDF, 381
 - MRC algorithm, 382, 384
 - Nakagami fading channels, 382
 - SC algorithm, 382
 - sensitivity, 381
 - shadowed fading channel, 383–385
 - short-term faded channel, 381
 - pdf, 314
 - polarization diversity, 318–319
 - Rayleigh faded channel, 315
 - received signal power, 315
 - SC algorithm
 - CDFs, 322
 - SNR expression, 321–322
 - SSC algorithm (*see* Switched and stay combining algorithm)
 - signal processing methods, 313
 - SNR, 316
 - space diversity, 317–318
 - time diversity, 319
 - types, 316
- E**
- Equal gain combining (EGC) algorithm, 324
 - Ergodic channel capacity
 - additive white Gaussian noise, 284, 285
 - cascaed short-term fading channel, 287
 - channel bandwidth, 285
 - density function, generalized K
 - distribution, 289–290
 - double Nakagami cascaded channels, 288
 - MeijerG function, 285
 - Nakagami faded channel, 285, 286
 - Nakagami-Hoyt channels, 287, 288
 - normalized average channel capacity, 285
 - quadruple cascaded channels, 287, 289
 - Rayleigh fading, 286
 - Rician faded channel, 286, 287
 - shadowed fading channels, 290, 291
 - triple cascaded channels, 287, 289
 - Erlang distribution, 18
 - Exponential distribution, 18–20
- F**
- F (Fisher-Snedecor) distribution, 20–21
 - Frequency diversity, 318
 - Frequency shift keying (FSK), 124–126, 141–142
- G**
- Gamma distribution, 21–23
 - Gaussian distribution, 33–35
 - Gaussian function, 301
 - Gaussian minimum shift keying (GMSK), 146–149
 - Generalized Bessel K (GBK) distribution, 65
 - Generalized gamma distribution, 25
 - definition, 22

- Generalized gamma distribution (*cont.*)
 - generalized gamma pdf, 24
 - normalization factor, 25
 - random variable, 24
 - scaling factor, 25
 - Stacy distribution, 24
 - two-sided generalized gamma pdf, 26
- Generalized K (GK) distribution, 344, 345
- Generalized selection combining (GSC)
 - algorithm, 361
 - average error probabilities, 408, 409
 - average SNR, 357
 - CDFs, 357–359, 408, 409
 - CDMA system, 353
 - densities and distributions, 359–360
 - gamma random variables, 359
 - joint pdf, 354–356
 - M_c signals, 354
 - Nakagami channels, 358, 360
 - Nakagami- m faded channels, 360, 361
 - normalized peak values, 360
 - outage probabilities, 407, 410
 - output SNR, pdfs, 408
 - RAKE reception, 353
 - Rayleigh channel, 354–356
 - three-branch diversity receiver, pdfs, 358, 359
- GK distribution. *See* Generalized K distribution
- GMSK. *See* Gaussian minimum shift keying

- K**
- Kibble's bivariate gamma distribution, 76
- Kurtosis coefficient, 10

- L**
- Laplace distribution, 27–28
- Laplace transforms, 11, 307
- 8-Level phase shift keying (8PSK)
 - demodulator, 158
 - modulator, 158
 - phase constellation, 156, 157
 - phase encoding, 156, 157
 - waveform, 159
- Lognormal distribution, 28–29

- M**
- Macrodiversity techniques
 - microdiversity systems
 - CDFs, 352
 - density functions, 348, 349
 - gamma pdf, 344
 - GK distribution, 344, 345
 - joint pdf, 345–346
 - MeijerG functions, 351
 - MRC diversity, 348, 349
 - MRC–SC, 345–347, 350–351
 - pdfs, 352, 353
 - shadowed fading channel, 349
 - short-term fading effects, 343
 - SNR, SC, 349–350
 - shadowing mitigation
 - CDF, SC algorithm, 341
 - dual correlated Nakagami channels, 342
 - multiple base stations, 340
 - normalized Gaussian variable, 341
 - SNR, 340, 342, 343
 - three-base station arrangement, 340, 341
- Marcum's Q functions, 3, 179–182
- M-ary phase shift keying (MPSK). *See* Binary phase shift keying
- M-ary quadrature amplitude modulation (MQAM), 139–141
- Matlab and Maple, 5
- Maximal ratio combining (MRC) algorithm, 448–450
 - Chebyshev inequality, 323
 - correlation coefficient
 - correlated branch expression, 334
 - density functions, 335, 336
 - SNR, fractional decline, 337
 - noise power, 323
 - processing algorithm, 322
 - signal power, 323
- McKay's bivariate gamma distribution, 76
- Meijer G function, 67, 68, 299–301, 304
- MGF. *See* Moment generating function
- Minimum shift keying (MSK)
 - modulator, 144, 145
 - power spectrum, 144
 - waveform, 144–146
- Modems
 - bandwidth requirement, 174
 - bit energy, 163
 - carrier regeneration and synchronization, 166–168
 - channel capacity, 175
 - complementary error function, 176–179
 - correlator, 114
 - cos() and sine() functions, 119
 - differentially encoded signals
 - coherent vs. noncoherent modems, 156

- DPSK, 154
 - error probability, 152
 - 8-level PSK (*see* 8-Level phase shift keying)
 - modified Bessel function, 153
 - noise variance, 153
 - noncoherent detection, 152
 - noncoherent receiver, 154, 155
 - non-Gaussian statistics, 152
 - phase encoding, 155
 - Rician statistics, 153
 - digital communication system, 110
 - digital modulation techniques, 117–118
 - digital signal bandwidth, 164–166
 - digital transmission, 110, 111
 - error function, 176
 - Euclidian distance, 120
 - gamma functions, 177–178
 - Gaussian Q function, 112
 - general nonlinear modulation schemes
 - DFM (*see* Digital frequency modulation)
 - error rates, 151
 - FSK, 141–142
 - GMSK, 146–149
 - MSK (*see* Minimum shift keying)
 - orthogonal M-ary FSK, 147, 149–151
 - gray coding, 110
 - inter symbol interference
 - cosine pulse shape, 183–185
 - eye pattern, 185, 186
 - impulse response, 182
 - roll-off factor, 183
 - Kronecker delta function, 118
 - Marcum's Q functions, 179–182
 - M-ary signaling, 110
 - M-ary transmission system, 118
 - matched filter, 114
 - modulation techniques
 - ASK, 121–122
 - BPSK (*see* Binary phase shift keying)
 - FSK, 124–126
 - PSK, 122–124
 - QAM, 125
 - N-dimensional orthogonal space, 118
 - noise power, 163
 - noise variance, 112
 - Nyquist criteria, 115, 117
 - OFDM
 - digital Fourier transforms principle, 161, 162
 - fast Fourier transform algorithm, 162
 - frequency domain representations, 160
 - inter channel interference, 160, 162
 - inverse fast Fourier transform approach, 162
 - subcarrier frequencies, 160–161
 - transmitter and receiver, 160, 161
 - optimum filter, impulse response, 113
 - phase mismatch
 - angular mismatch, 168, 169
 - coherent QPSK, 172
 - correlation function, 171
 - fixed phase mismatch, 168, 169
 - jitter, 170
 - matched filter, 170
 - normalized timing offset, 171–172
 - random phase mismatch, 168, 170
 - timing offset, 170
 - power spectral density, 113
 - probability of error, 119–121
 - probability density function, 112
 - pulse shapes, 114–116
 - Q functions, 176, 179
 - Shannon's channel capacity theorem, 174
 - signal-to-noise ratio, 163
 - sin c pulse, 116
 - spectral and power efficiencies, 174
 - symbol energy, 163
 - zero mean Gaussian white noise, 111
 - Moment generating function (MGF), 11, 367
 - MQAM. *See* M-ary quadrature amplitude modulation
 - MRC algorithm. *See* Maximal ratio combining algorithm
 - MSK. *See* Minimum shift keying
 - Multipath diversity, 320
 - Multipath propagation phenomenon, 3
- N**
- Nakagami channels, 426–427
 - bit error rates
 - average error probability, 442, 444, 445
 - hypergeometric function, 443
 - MeijerG function, 443
 - pdf, 436
 - Nakagami distribution, 30–32
 - Nakagami fading
 - AF, 211
 - CDF, 207–208
 - channel, 303
 - chi-square density function, 208–209
 - clustering/bunching concept, 208
 - density moments, 207
 - Gaussian densities, 209, 210

Nakagami fading (*cont.*)

- Nakagami- m pdf moments, 208, 209
- received signal envelope, 206–207
- Rician envelope densities, 209–211

Nakagami-inverse Gaussian distribution, 226

Nakagami- m distribution

- CDF, 325, 328–330
- density functions, 328–329
- EGC algorithm, 327
- Matlab, 328
- MRC algorithm, 325–327
- received signal power, 325
- SC algorithm, 325, 326
- SNR improvement, 329
- statistical model, 324

Nakagami-N-gamma channels, 4

Natural logarithm, 303

Non-central chi-squared distribution, 32–33

Nyquist criteria, 115, 117

O

Orthogonal frequency division multiplexing (OFDM), 3

- digital Fourier transforms principle, 161, 162
- fast Fourier transform algorithm, 162
- frequency domain representations, 160
- inter channel interference, 160, 162
- inverse fast Fourier transform approach, 162
- subcarrier frequencies, 160–161
- transmitter and receiver, 160, 161

Ppdf. *See* Probability density function

Phase shift keying (PSK), 122–124

Poisson distribution, 35

Polarization diversity, 318–319

Probability and statistics concepts

- bivariate correlated distributions
 - gamma pdf, 76–77
 - generalized gamma pdf, 77–78
 - Nakagami pdf, 75–76
 - normal pdf, 73–75
 - Rician distribution, 79
 - Weibull pdf, 78
- CDF, 8–9
- Chebyshev inequality, 94–95
- Chernoff bound, 96–97
- CHF, 10–11, 57
- CLT, 46–47
- conditional densities, 44

correlation coefficient, 45

covariance, 45

decision theory and error rates (*see*

Decision theory and error rates)

expected value, random variables, 44–45

independent random variables, 45

joint densities, 43

joint pdf, multiple random variable

- CDF differentiation, 56, 57
- diversity combining algorithm, 53
- Jacobian, 51, 52
- Leibniz's rule, 55
- probability volume calculation, 55
- region of interest, 53, 54
- two-scaled random variables, 52

Laplace transforms, 11

marginal densities, 43–44

moment generating functions, 11

order statistics

- bivariate correlated pdf, 83
- bivariate lognormal densities, 84
- bivariate Nakagami pdf, 82
- bivariate Rayleigh pdf, 82–83
- exponential pdf, 82
- generalized Bernoulli trial, 81
- joint CDF, 80
- lognormal random variables, 85
- Marcum Q function, 83
- selection combining algorithm, 79
- short-term fading, indoor wireless channels, 84

orthogonality, 45

pdf, 10

- beta distribution, 11–13
- binomial distribution, 13–15
- Cauchy distribution, 15–16
- chi-squared distribution, 16–18
- Erlang distribution, 18
- exponential distribution, 18–20
- F distribution, 20–21
- gamma distribution, 21–23
- Gaussian distribution, 33–35
- generalized gamma distribution (*see* Generalized gamma distribution)
- Laplace distribution, 27–28
- lognormal distribution, 28–29
- Nakagami distribution, 30–32
- non-central chi-squared distribution, 32–33
- Poisson distribution, 35
- Rayleigh distribution, 36–38
- rectangular/uniform distribution, 38–40

- student's t distribution (*see* Student's t distribution)
 - Weibull distribution, 41–43
 - random variable transformations
 - Bessel function, 59, 63
 - doubling formula, 62
 - gamma random variable sum, 62, 66
 - Gaussian, chi-squared and student t distributions relationship, 72–73
 - GBK distribution, 65
 - K distribution, 64
 - lognormal fading conditions, 68
 - marginal density function, 58
 - Meijer's G function, 67, 68
 - monotonic transformation property, 63
 - Nakagami- m distributed envelope values, 69
 - phase statistics, 59
 - Rician factor, 60–61
 - SNR, 70, 71
 - stochastic processes, 97
 - autocovariance, 99
 - ergodicity concept, 100
 - first order density function, 98
 - higher-order density functions, 99
 - power spectral density, 100
 - second order density function, 98
 - spectral density, 101
 - thermal noise, 101
 - time domain function, 97
 - wide stationary sense process, 100
 - $Y = g(X)$, pdf and CDF derivation
 - filter, input-output relationship, 47, 48
 - many-to-one transformation, 49, 50
 - monotonic transformation, 47, 48
 - non-monotonic transformation, 48, 49
 - $Z = X + Y$, pdf, 50–51
 - Probability density function (pdf), 10, 198
 - beta distribution, 11–13
 - binomial distribution, 13–15
 - Cauchy distribution, 15–16
 - chi-squared distribution, 16–18
 - Erlang distribution, 18
 - exponential distribution, 18–20
 - F distribution, 20–21
 - gamma distribution, 21–23
 - Gaussian distribution, 33–35
 - Gaussian pdf, 215
 - generalized gamma distribution (*see* Generalized gamma distribution)
 - Laplace distribution, 27–28
 - lognormal distribution, 28–29
 - Nakagami channels, 436
 - Nakagami distribution, 30–32
 - Nakagami-Hoyt pdf, 282, 283
 - Nakagami- m pdf, 201
 - non-central chi-squared distribution, 32–33
 - Poisson distribution, 35
 - Rayleigh channels, 434–435
 - Rayleigh distribution, 36–38
 - rectangular/uniform distribution, 38–40
 - Rician fading, 206
 - second order statistics
 - conditional pdf, 293
 - envelope pdf, 296
 - SNR, joint pdf, 292
 - shadowed fading channels
 - N interfering channels, 439
 - probability density functions, 437, 438, 440, 441
 - signal-to-CCI ratio, 437, 438
 - SNR, density function, 436, 437, 439
 - student's t distribution (*see* Student's t distribution)
 - Weibull distribution, 41–43
 - PSK. *See* Phase shift keying
- Q**
- Quadrature amplitude modulation (QAM), 125
 - Quaternary phase shift keying (QPSK)
 - modulator, 131, 132
 - offset-QPSK scheme, 133, 134
 - phase constellation, 131
 - $\pi/4$ -QPSK, 133–136
 - time domain waveforms, 131, 132
 - waveforms, 130
- R**
- RAKE receiver, 320
 - Rayleigh channels
 - bit error rates, 421, 441–442
 - N cochannels, 419
 - outage probability, 418, 419
 - CCI channels, 425, 426
 - desired signal power, 424, 425
 - multiple cochannels, 424
 - SIR/q, 422
 - Z_0/Z_T , 423
 - pdf, 434–435
 - Poisson random variable, 424
 - protection ratio, 420
 - signal-to-interference, 420
 - threshold and protection factor, 421
 - Rayleigh distribution, 36–38

- Rayleigh fading
 AF, 200–201
 amplitude, 197
 exponential densities, 198, 199
 Gaussian random variables, 198
 histogram, 198–200
 inphase and quadrature notation, 197
 multipath phenomenon, 197
 Nakagami- m pdf, 201
 pdf, 198
 Rayleigh density function, 200
- Rayleigh-lognormal channel, 221
- Rectangular/uniform distribution, 38–40
- Rician factor, 60–61
- Rician fading
 AF, 203, 204
 average power, 203, 204
 density function, 201, 202, 206
 error function, 206
 Gaussian statistics, 204–205
 Marcum Q function, 203
 mean and second moments, 202–203
 phase, pdf, 206
 received power, 201
 Rician factor, 202, 205
- S**
- Selection combining (SC) algorithm, 321–322
- Shadowed fading channels
 AF, 225–226
 BER, 255, 256
 average error rates, 446, 447
 BPSK, 256–259
 CCI effect, 446
 CDF, 259
 cochannels, 448
 fading channel, 259
 moderately shadowed channel, 260, 262
 Nakagami interferers, 445
 severely shadowed channel, 261
- cascaed approach
 AF, 242, 243
 CDF, 242, 244, 245
 central limit theorem, 237
 density function, 238, 240, 241
 digamma and trigamma function, 238
 gamma parameter, 239
 gamma random variables, 238
 GK distribution, 236
 inverse Gaussian distribution, 237
- MeijerG function and Bessel function, 238, 240
- Nakagami- N -gamma distribution, 237
 outage probabilities and error rates, 241
 shadowing, higher level, 240, 241
- conditional density function, 429
- equivalent gamma model, 429
- generalized gamma model, 223–225
- Nakagami-gamma/generalized K models, 220–222
- Nakagami-inverse-Gaussian model, 221–223
- Nakagami-lognormal models
 average power, 218
 density functions, 219
 vs. short term fading, 219, 220
- outage probability
 CDF, 271, 273
 density function, 271, 272
 multiple interfering shadowed fading channels, 432, 433
- Nakagami-cascaded gamma channel, 268, 270
- Nakagami inverse Gaussian channel, 271
- Nakagami-lognormal channel, 267–271
- Nakagami- m distributed cochannel, 429, 430
- Nakagami parameter, 268, 269
- single interfering channel, 431, 432
- pdf, 440, 441
- N interfering channels, 439
 signal-to-CCI ratio, 437, 438
 SNR, density function, 436, 437, 439
 shadowing density, 429
- Shannon's channel capacity theorem, 174
- Short-term fading, 194
 attenuation, 195
 average power, gamma pdf moments, 211
 CDF, 213
 gamma fading channel, 211, 214, 215
 generalized gamma channel, 212–215
- Nakagami fading
 AF, 211
 CDF, 207–208
 chi-square density function, 208–209
 clustering/bunching concept, 208
 density moments, 207
 Gaussian densities, 209, 210
 Nakagami- m pdf moments, 208, 209
 received signal envelope, 206–207
 Rician envelope densities, 209–211

- Rayleigh fading
 - AF, 200–201
 - amplitude, 197
 - exponential densities, 198, 199
 - Gaussian random variables, 198
 - histogram, 198–200
 - inphase and quadrature notation, 197
 - multipath phenomenon, 197
 - Nakagami- m pdf, 201
 - pdf, 198
 - Rayleigh density function, 200
 - Rician fading
 - AF, 203, 204
 - average power, 203, 204
 - density function, 201, 202, 206
 - error function, 206
 - Gaussian statistics, 204–205
 - Marcum Q function, 203
 - mean and second moments, 202–203
 - phase, pdf, 206
 - received power, 201
 - Rician factor, 202, 205
 - statistical characteristics, 196
 - Weibull fading model, 213–215
 - Signal transmission and deterioration, 1
 - Skewness coefficient, 10
 - Space diversity, 317–318
 - SSC algorithm. *See* Switched and stay combining algorithm
 - Stacy distribution, 24
 - Statistical decision theory, 3
 - Statistical distributions, 2
 - Stochastic processes, 97
 - autocovariance, 99
 - ergodicity concept, 100
 - first order density function, 98
 - higher-order density functions, 99
 - power spectral density, 100
 - second order density function, 98
 - spectral density, 101
 - thermal noise, 101
 - time domain function, 97
 - wide stationary sense process, 100
 - Student's t distribution, 41
 - cumulative distributions functions, 41, 42
 - Gaussian and Cauchy distributions, 39
 - moments of, 40
 - random variable, 40
 - Switched and stay combining (SSC) algorithm
 - CDFs, 330–331
 - logic and switching circuits, 329
 - Nakagami parameter, SNR improvement, 332, 333
 - vs. SC dual branch, density functions, 331, 332
 - vs. SC SNR enhancement, 333, 334
- T**
- Thermal noise, 101
 - Time diversity, 319
 - Time domain function, 97
- W**
- Weibull distribution, 41–43
 - Weibull fading model, 213–215
 - Wireless channels, 1, 2, 193
 - attenuation, 195
 - average probability of error
 - bit error rate (*see* Bit error rate)
 - coherent BPSK modem, 433
 - probability density function (*see* Probability density function)
 - cascaded models
 - cascaded fading channels (*see* Cascaded fading channels)
 - cooperative diversity, 231
 - double Rician channels, 245–246
 - multiple scattering, 231
 - N*Weibull channels, 245
 - shadowed fading channels (*see* Shadowed fading channels)
 - composite model
 - cluster power, 227
 - double Nakagami fading and Nakagami- m fading, 228–229
 - double Rayleigh and Rayleigh densities, 228
 - gamma-Weibull/Weibull-Weibull channel, 230
 - “miniclusters,” 230
 - received signal power, 226–227
 - scaling factors, 227
 - signal-to-noise ratio, 230–231
 - Doppler fading, 196
 - ergodic channel capacity
 - additive white Gaussian noise, 284, 285
 - cascaded short-term fading channel, 287
 - channel bandwidth, 285
 - density function, generalized K distribution, 289–290
 - double Nakagami cascaded channels, 288
 - MeijerG function, 285
 - Nakagami faded channel, 285, 286

Wireless channels (*cont.*)

- Nakagami-Hoyt channels, 287, 288
- normalized average channel capacity, 285
- quadruple cascaded channels, 287, 289
- Rayleigh fading, 286
- Rician faded channel, 286, 287
- shadowed fading channels, 290, 291
- triple cascaded channels, 287, 289
- error rates
 - cascaded channels, 253, 255, 256
 - complimentary error function, 248
 - generalized gamma channel, 252–254
 - ideal Gaussian channel, 247
 - lognormal channel, 252, 253
 - lognormal random variable, 251–252
 - lognormal shadowing, 251
 - Nakagami channels, 250–251
 - Nakagami-Hoyt channels, 283, 284
 - power penalty, 247, 249
 - Rayleigh fading channel, 248
 - Rician channel, 251
 - shadowed fading channels (*see* Shadowed fading channels)
 - signal-to-noise ratio, 249
 - SNR correction factor, 252
 - Weibull channels, 253, 254
- fading channel, 304
- frequency selective fading channels, 196
- general fading models
 - AF, 283
 - central limit theorem, 274
 - cluster based scattering model, 274, 275
 - Gaussian random variables, 279
 - generalized Nakagami pdf, 282
 - η - μ densities, 276
 - α - η - μ distributions, 273
 - Hoyt fading channel, 278–279
 - κ - μ density, 280, 281
 - α - λ - μ distributions, 273
 - modified Bessel function, 277
 - Nakagami-Hoyt distribution, 276
 - Nakagami-Hoyt pdf, 282, 283
 - Nakagami parameter, 277, 278
 - Rice distribution, 279
 - total power, 280
 - unified model, 273
- long-term fading, 195
- multipath transmission, 194
- multiple scattering, 195
- outage probability
 - cascaded N^* -Nakagami channel, 266, 267
 - CDF, 265
 - generalized gamma fading channel, 264, 265
 - Nakagami channels, 426–428
 - Nakagami-Hoyt channels, 283, 284
 - Nakagami- m faded channel, 263
 - Rayleigh channels (*see* Rayleigh channels)
 - shadowed fading channels (*see* Shadowed fading channels)
 - SNR, 262
 - Weibull channels, 265, 266
- second order statistics
 - average fade duration, 292, 294, 296
 - conditional pdf, 293
 - envelope pdf, 296
 - level crossing rates, 292
 - maximum Doppler frequency shift, 293
 - Nakagami fading channel, 297
 - Rayleigh faded channel, 292–293
 - Rician channel, LCR, 295
 - shadowed fading channels, 297, 298
 - SNR, joint pdf, 292
 - temporal characteristics, 291
 - transmitter and receiver effects, 290–291
 - Weibull fading, 295–296
- shadowed fading channels, 196 (*see also* Shadowed fading channels)
- shadowing models
 - AF, 216
 - definition, 215
 - gamma distribution, 216
 - Gaussian pdf, 215
 - lognormal density function, 216, 217
 - shadowing parameter vs. gamma parameter, 217, 218
- short-term fading (*see* Short-term fading)
- variance ratio, inphase and quadrature component, 275, 278