

# Contents

<b>1</b>	<b>Overview .....</b>	<b>1</b>
1.1	Outline .....	1
	References .....	5
<b>2</b>	<b>Concepts of Probability and Statistics .....</b>	<b>7</b>
2.1	Introduction .....	7
2.2	Random Variables, Probability Density Functions, and Cumulative Distribution Functions .....	8
2.3	Characteristic Functions, Moment Generating Functions and Laplace Transforms .....	10
2.4	Some Commonly Used Probability Density Functions .....	11
2.4.1	Beta Distribution .....	11
2.4.2	Binomial Distribution .....	13
2.4.3	Cauchy Distribution .....	15
2.4.4	Chi-Squared Distribution .....	16
2.4.5	Erlang Distribution .....	18
2.4.6	Exponential Distribution .....	18
2.4.7	$F$ (Fisher-Snedecor) Distribution .....	20
2.4.8	Gamma Distribution .....	21
2.4.9	Generalized Gamma Distribution .....	22
2.4.10	Inverse Gaussian (Wald) Distribution .....	26
2.4.11	Laplace Distribution .....	27
2.4.12	Lognormal Distribution .....	28
2.4.13	Nakagami Distribution .....	30
2.4.14	Non-Central Chi-Squared Distribution .....	32
2.4.15	Normal (Gaussian) Distribution .....	33
2.4.16	Poisson Distribution .....	35
2.4.17	Rayleigh Distribution .....	36
2.4.18	Rectangular or Uniform Distribution .....	38

2.4.19	Student's $t$ Distribution .....	39
2.4.20	Weibull Distribution .....	41
2.5	Joint, Marginal and Conditional Densities .....	43
2.6	Expectation, Covariance, Correlation, Independence, and Orthogonality .....	44
2.7	Central Limit Theorem .....	46
2.8	Transformation of Random Variables .....	47
2.8.1	Derivation of the pdf and CDF of $Y = g(X)$ .....	47
2.8.2	Probability Density Function of $Z = X + Y$ .....	50
2.8.3	Joint pdf of Functions of Two or More Random Variables .....	51
2.8.4	Use of CHF to Obtain pdf of Sum of Random Variables .....	57
2.8.5	Some Transformations of Interest in Wireless Communications .....	58
2.9	Some Bivariate Correlated Distributions of Interest in Wireless Communications .....	73
2.9.1	Bivariate Normal pdf .....	73
2.9.2	Bivariate Nakagami pdf .....	75
2.9.3	Bivariate Gamma pdf .....	76
2.9.4	Bivariate Generalized Gamma pdf .....	77
2.9.5	Bivariate Weibull pdf .....	78
2.9.6	Bivariate Rician Distribution .....	79
2.10	Order Statistics .....	79
2.10.1	A Few Special Cases of Order Statistics in Wireless Communications .....	82
2.11	Decision Theory and Error Rates .....	85
2.11.1	Gaussian Case .....	86
2.11.2	Non-Gaussian Case .....	90
2.12	Upper Bounds on the Tail Probability .....	94
2.12.1	Chebyshev Inequality .....	94
2.12.2	Chernoff Bound .....	96
2.13	Stochastic Processes .....	97
2.14	Summary .....	102
	References .....	102
<b>3</b>	<b>Modems for Wireless Communications .....</b>	<b>109</b>
3.1	Introduction .....	109
3.2	Optimum Receiver, Pulse Shaping, and Nyquist's Criteria .....	110
3.3	Efficiency of Digital Modulation Techniques .....	117
3.4	Geometric Representation of Signals and Orthonormal Functions .....	118
3.5	Modulation Techniques .....	121
3.5.1	Amplitude Shift Keying .....	121
3.5.2	Phase Shift Keying .....	122

3.5.3	Frequency Shift Keying.....	124
3.5.4	Amplitude and Phase Shift Keying.....	125
3.5.5	Limitations of BPSK and Justification for MPSK.....	127
3.6	General Nonlinear Modulation Schemes.....	141
3.6.1	Frequency Shift Keying.....	141
3.6.2	Digital Frequency Modulation (DFM) and Minimum Shift Keying (MSK).....	142
3.6.3	Gaussian Minimum Shift Keying.....	146
3.6.4	Orthogonal M-ary FSK.....	147
3.6.5	Error Rates for MSK, OQPSK, $\pi/4$ QPSK, and GMSK.....	151
3.7	Error Rates for Differentially Encoded Signals.....	151
3.8	Orthogonal Frequency Division Multiplexing.....	159
3.9	Summary.....	163
	Appendix.....	163
	References.....	187
<b>4</b>	<b>Modeling of Fading and Shadowing.....</b>	<b>193</b>
4.1	Introduction.....	193
4.2	Background.....	194
4.3	Models for Short-Term Fading.....	196
4.3.1	Rayleigh Fading.....	197
4.3.2	Rician Fading.....	201
4.3.3	Nakagami Fading.....	206
4.3.4	Gamma, Generalized Gamma, and Weibull Fading.....	211
4.4	Models for Shadowing.....	215
4.5	Models for Shadowed Fading Channels.....	218
4.5.1	Nakagami-Lognormal Models.....	218
4.5.2	Nakagami-Gamma or Generalized $K$ Models.....	220
4.5.3	Nakagami-Inverse-Gaussian Model.....	221
4.5.4	Generalized Gamma Model.....	223
4.5.5	Amount of Fading in Shadowed Fading Channels.....	225
4.6	Composite Model for Fading, Shadowing, and Shadowed Fading.....	226
4.7	General Cascaded Models.....	231
4.7.1	Statistical Background of Cascaded Fading Channels.....	232
4.7.2	Cascaded Approach to Shadowed Fading Channels.....	236
4.7.3	$N$ *Weibull Channels.....	245
4.7.4	Double Rician Channels.....	245
4.8	Comparison of Different Models.....	246
4.8.1	Average Probability of Error.....	247
4.8.2	Outage Probability.....	262
4.9	Other General Fading Models.....	273
4.10	A few Additional Quantitative Measures of Fading and Shadowing.....	283

4.10.1	Ergodic Channel Capacity .....	284
4.10.2	Second Order Statistics of Fading, Shadowing, and Shadowed Fading Channels.....	290
4.11	Summary .....	298
	Appendix .....	299
	References.....	308
<b>5</b>	<b>Diversity Techniques .....</b>	<b>313</b>
5.1	Introduction .....	313
5.2	Concept of Diversity .....	314
5.2.1	Space Diversity.....	317
5.2.2	Frequency Diversity.....	318
5.2.3	Polarization Diversity .....	318
5.2.4	Time Diversity .....	319
5.2.5	Multipath Diversity .....	320
5.3	Diversity Combining Algorithms .....	321
5.3.1	Selection Combining.....	321
5.3.2	Maximal Ratio Combining.....	322
5.3.3	Equal Gain Combining.....	324
5.3.4	Preliminary Comparison of the Three Combining Algorithms.....	324
5.3.5	Selection Combining and Switched and Stay Combining .....	329
5.3.6	Effects of Branch Correlation on Combining Algorithms .....	334
5.4	Shadowing Mitigation and Macrodiversity.....	340
5.5	Macro- and Microdiversity Systems (Hybrid Diversity) .....	343
5.6	Generalized Selection Combining .....	353
5.7	Quantitative Comparison of Diversity Combining Algorithms ....	361
5.7.1	Amount of Fading.....	362
5.7.2	Average Probability of Error.....	366
5.7.3	Outage Probability .....	379
5.8	Diversity in Generalized Gamma and Weibull Channels .....	385
5.9	Diversity in Cascaded Nakagami Channels .....	395
5.10	Generalized Selection Combining.....	408
5.11	Summary .....	410
	References.....	411
<b>6</b>	<b>Interference in Wireless Channels .....</b>	<b>417</b>
6.1	Introduction .....	417
6.2	Outage Probabilities.....	418
6.2.1	Rayleigh Channels .....	418
6.2.2	Nakagami Channels .....	426
6.2.3	Shadowed Fading Channels.....	427
6.3	Average Probability of Error .....	433

6.3.1	Probability Density Function (Rayleigh Channels) .....	434
6.3.2	Probability Density Function (Nakagami Channels) .....	436
6.3.3	Probability Density Function (Shadowed Fading Channels).....	436
6.3.4	Error Rates (Rayleigh Channels) .....	441
6.3.5	Error Rates (Nakagami Channels).....	442
6.3.6	Error Rates (Shadowed Fading Channels).....	445
6.3.7	Error Rates Following Diversity.....	448
6.4	Summary .....	451
	References.....	451
<b>Index</b>	.....	<b>455</b>



<http://www.springer.com/978-1-4614-0366-1>

Fading and Shadowing in Wireless Systems

Shankar, P.M.

2012, XIV, 466 p., Hardcover

ISBN: 978-1-4614-0366-1