

Table of Contents

1. Introduction	1
1.1 Overview of Communication Systems	1
1.2 Spread-Spectrum Communications	2
1.2.1 Direct-Sequence Spread-Spectrum Technique	3
1.2.2 Frequency-Hopping Spread-Spectrum Technique	4
1.3 Advantages of Spread-Spectrum Systems	6
1.3.1 Mitigation of Multipath Effects	6
1.3.2 Averaging of Signal Quality in Multiple-User Environments	7
1.3.3 Reduction of Frequency Planning Effort	7
1.3.4 Increase in System Capacity	9
1.4 Applications of Spread-Spectrum Communications	9
1.5 Chaos-Based Communications	10
1.5.1 Chaos	10
1.5.2 Application of Chaos to Communications	11
1.6 Benefits and Challenges	15
1.7 What Is This Book About?	16
2. Chaos-Based Digital Modulation and Demodulation Techniques	17
2.1 From Conventional to Chaos-Based Digital Communications	17
2.2 Classifications of Chaos-Based Communication Systems	18
2.3 Chaos Shift Keying	20
2.3.1 Coherent Demodulation Based on Correlation	21
2.3.2 Non-Coherent Demodulation Based on Bit Energy Calculation	22
2.4 Differential Chaos Shift Keying	25
2.5 Other Modulation Schemes	30
2.5.1 Chaotic On-Off-Keying	30
2.5.2 Frequency-Modulated DCSK	30
2.5.3 Correlation Delay Shift Keying	32
2.5.4 Symmetric Chaos Shift Keying	32
2.5.5 Quadrature Chaos Shift Keying	34
2.6 Discrete-Time Baseband Equivalent Models	35

2.6.1	Bandpass System	35
2.6.2	Lowpass Equivalent Model	36
2.6.3	Discrete-Time Lowpass Equivalent Model	37
2.6.4	Derivation of Average Bit-Energy-to-Noise-Power-Spectral-Density Ratio	38
3.	Performance Analysis Methods for Coherent Chaos-Shift-Keying Systems	41
3.1	Review of the Chaos-Shift-Keying (CSK) System	42
3.2	Analysis of the CSK System with Multiple Access	44
3.2.1	Transmitter Structure	44
3.2.2	Receiver Structure	44
3.2.3	Derivation of Bit Error Rate	46
3.3	Simulations and Evaluation	51
3.3.1	Users Using Distinct Chaotic Maps	53
3.3.2	Same Chaotic Map Used by All Users	53
	Appendix 3A: Derivation of variances relevant to the analysis of multiple access CSK system	58
	Appendix 3B: Derivation of the statistical properties for the chaotic sequences generated by the logistic map and the cubic map . .	60
4.	Performance Analysis Methods for Non-Coherent Differential Chaos-Shift-Keying Systems	63
4.1	Review of the Differential Chaos-Shift-Keying (DCSK) System	63
4.2	Multiple Access DCSK System	65
4.3	Time-Delay-Based Multiple Access DCSK System	67
4.3.1	Frame Structure of the Transmitted Signal	67
4.3.2	Receiver Structure	70
4.3.3	Derivation of Bit Error Rate	71
4.3.4	Simulations and Evaluation	78
4.4	Permutation-Based Multiple Access DCSK System	84
4.4.1	System Description	84
4.4.2	Derivation of Bit Error Rate	87
4.4.3	Simulations and Evaluation	91
	Appendix 4: Derivation of variances and covariances relevant to the analysis of time-delay-based multiple access DCSK system	94
5.	Anti-Jamming Performance of Chaos-Based Digital Communication Systems Under Narrowband Sine-Wave Jammers	97
5.1	Systems Subject to Narrowband Sine-Wave Jammers	97
5.2	Analysis of Anti-jamming Performance	99
5.2.1	Coherent CSK System	99
5.2.2	Non-Coherent DCSK System	106
5.3	Simulations and Evaluation	112

6. Anti-Jamming Performance of Chaos-Based Digital Communication Systems Under Wideband Pulsed-Noise Jammers	119
6.1 Systems Subject to Wideband Pulse-Noise Jammers	119
6.2 Analysis of Performance Under Pulsed-Noise Jammer	120
6.2.1 Slowly Switching Jammer	122
6.2.2 Fast Switching Jammer	128
6.3 Simulations and Evaluation	131
6.3.1 Slowly Switching Jammer	131
6.3.2 Fast Switching Jammer	132
Appendix 6A: Derivation of covariances	143
Appendix 6B: Derivation of variances	144
Appendix 6C: Derivation of the statistical properties for the chaotic sequences generated by Chebyshev maps of degree larger than one	145
7. Coexistence of Chaos-Based and Conventional Narrowband Digital Communication Systems	149
7.1 Overview of the Problem	149
7.2 System Description	150
7.3 Performance Analysis of Combined CSK-BPSK System	151
7.3.1 Performance of the CSK System in Combined CSK-BPSK System	152
7.3.2 Performance of the BPSK System in Combined CSK-BPSK System	158
7.4 Performance Analysis of Combined DCSK-BPSK System	161
7.4.1 Performance of the DCSK System in Combined DCSK-BPSK System	161
7.4.2 Performance of the BPSK System in Combined DCSK-BPSK System	167
7.5 Simulations and Evaluation	170
Appendix 7A: Derivation of covariances and variances relevant to the analysis of combined CSK-BPSK system	178
Appendix 7B: Derivation of $E[x_k x_m^2]$ for chaotic sequences generated by the logistic map	181
8. Coexistence of Chaos-Based and Conventional Spread-Spectrum Systems	183
8.1 System Overview	183
8.2 Analysis of Bit Error Performance	184
8.2.1 Coherent CSK System	184
8.2.2 Non-Coherent DCSK System	190
8.3 Simulations and Evaluation	194
Appendix 8: Derivation of covariances and variances relevant to the analysis of CSK system	200

Chaos-Based Digital Communication Systems
Operating Principles, Analysis Methods, and
Performance Evaluation

Lau, F.C.M.; Tse, C.K.

2003, XII, 228 p. 70 illus., Hardcover

ISBN: 978-3-540-00602-2