21世纪
信息与通信技术教程

英文版

SPREAD SPECTRUM
Communications Handbook

扩频通信技术教程

MARVIN K · SIMON JIM K · OMURA ROBERT A · SCHOLTZ BARRY K · LEVITT
编 著

Mc Graw Hill Education

人民邮电出版社
POSTS & TELECOMMUNICATIONS PRESS

21 世纪信息与通信技术教程

扩频通信技术教程

（英文版）

SPREAD SPECTRUM Communications Handbook

MARVIN K. SIMON　JIM K. OMURA
ROBERT A. SCHOLTZ　BARRY K. LEVITT
编著

人民邮电出版社

图书在版编目（CIP）数据

扩频通信技术教程 /（美）西蒙（Simon, M.K.）等编著.
—北京：人民邮电出版社，2002.8
21 世纪信息与通信技术教程
ISBN 7-115-10437-9
Ⅰ. 扩… Ⅱ. 西… Ⅲ. 宽带通信系统－高等学校－教材－英文
Ⅳ. TN914.42
中国版本图书馆 CIP 数据核字（2002）第 051644 号

21 世纪信息与通信技术教程

扩频通信技术教程（英文版）

◆ 编　　著　MARVIN K · SIMON　JIM K · OMURA
ROBERT A · SCHOLTZ　BARRY K · LEVITT
责任编辑　王晓明

◆ 人民邮电出版社出版发行　北京市崇文区夕照寺街 14 号
邮编　100061　电子函件　315@ptpress.com.cn
网址　http://www. ptpress.com.cn
读者热线　010-67180876
北京汉魂图文设计有限公司制作
北京朝阳展望印刷厂印刷
新华书店总店北京发行所经销

◆ 开本：850×1168　1/32
印张：39.125　2002 年 8 月第 1 版
印数：1-2 000 册　2002 年 8 月北京第 1 次印刷
著作权合同登记　图字：01-2002-3519 号
ISBN 7-115-10437-9/TN · 1901

定价：61.00 元

本书如有印装质量问题，请与本社联系　电话：（010）67129223

内 容 提 要

本书是一本专门阐述分析扩频通信技术原理的教程类图书。书中内容涉及了扩频通信技术的基本概念与系统模型、系统的一般性分析、伪噪声发生器、相干直接序列系统、非相干跳频系统、相干调制技术、差分相干调制技术、直接序列接收机的伪噪声获取、直接序列接收机的伪噪声跟踪、跳频接收机的时间同步与频率同步、多址等等。

本书不仅理论性强，而且同时也兼顾了实际工程应用方面的需要，因此，适合各类院校的通信专业高年级师生及研究生作为教材使用，也可作为从事通信科研或通信应用工作的技术人员的参考读物。

TN914/52

版 权 声 明

Marvin K. Simon Jim K.Omura Robert A.Scholtz Barry K.Levitt
SPREAD SPECTRUM Communications Handbook
ISBN: 0-07-138215-1
Copyright © 2002 by the McGraw-Hill Companies, Inc.

Original language published by The McGraw-Hill Companies, Inc. All Rights reserved. No part of this publication may be reproduced or distributed in any means, or stored in a database or retrieval system, without the prior written permission of the publisher.
Authorized English language reprint edition jointly published by McGraw-Hill Education (Asia) Co. and Posts & Telecommunications Press. This edition is authorized for sale in the People's Republic of China only, excluding Hong Kong, Macao SAR and Taiwan. Unauthorized export of this edition is a violation of the Copyright Act. Violation of this Law is subject to Civil and Criminal Penalties.

本书英文影印版由人民邮电出版社和美国麦格劳-希尔教育出版(亚洲)公司合作出版。此版本仅限在中华人民共和国境内（不包括香港、澳门特别行政区及台湾）销售。未经许可之出口，视为违反著作权法，将受法律之制裁。
未经出版者预先书面许可，不得以任何方式复制或抄袭本书的任何部分。

本书封面贴有 McGraw-Hill 公司激光防伪标签，无标签者不得销售。
北京市版权局著作权合同登记号： 01-2002-3519 号

此为试读，需要完整PDF请访问：www.ertongbook.com

PREFACE

In the nine years since the publication of the first edition of *Spread Spectrum Communications,* the world's political situation has changed considerably. The U.S. Department of Defense has reduced its support for the development of new communication systems as well as their acquisition. One might question the need for a second edition of a book written about robust techniques for anti-jamming (AJ) and low-probability-of-intercept (LPI) communications.

However, while it is already painfully clear that the close of the Cold War has not ended warfare, the past decade has also ushered in a new era of mobile communications. The qualities that make spread-spectrum techniques useful in military communications—fine time-resolution, low power-density, privacy, and a high immunity to interference—are also extremely desirable in today's mobile communications systems. Encouraged by enlightened FCC actions, spread-spectrum technology is being transferred from the Department of Defense to the arena of commercial mobile cellular communications. The emerging markets for spread-spectrum systems have the potential to dwarf those of the past.

Are the design techniques for military communication systems truly applicable to the commercial environment? Does yesteryear's jammer have anything to teach us about managing multiple-user noise in a spread-spectrum multiple-access radio network? The answer—an unqualified "yes"—is attested to by the successes of companies that are penetrating the commercial marketplace with spread-spectrum products.

This revised edition contains new material on the emerging commercial applications of spread-spectrum techniques as well as minor modifications to the book's original fourteen chapters. We believe that since it is based on sound engineering principles and is not bound to a particular implementation technology, it will retain its usefulness for the foreseeable future.

Marvin K. Simon
Jim K. Omura
Robert A. Scholtz
Barry K. Levitt

PREFACE TO FIRST EDITION

Not more than a decade ago, the discipline of spread-spectrum (SS) communications was primarily cloaked in secrecy. Indeed, most of the information available on the subject at that time could be found only in documents of a classified nature.

Today the picture is noticeably changed. The open literature abounds with publications on SS communications, special issues of the *IEEE Transactions on Communications* have been devoted to the subject, and the formation of an annual conference on military communications, MILCOM, now offers a public forum for presentation of unclassified (as well as classified) papers dealing with SS applications in military systems. On a less formal note, many tutorial and survey papers have recently appeared in the open literature, and presentations on a similar level have taken place at major communications conferences. Finally, as further evidence we cite the publication of several books dealing either with SS communications directly or as part of the more general electronic countermeasures (ECM) and electronic counter-counter measures (ECCM) problem. References to all these forms of public documentation are given in Section 1.7 of Chapter 1, Part 1.

The reasons for this proliferation can be traced to many sources. While it is undoubtedly true that the primary application of SS communications still lies in the development of enemy jam-resistant communication systems for the military, largely within the confines of classified programs, the emergence of other applications, in which both the military and civilian sectors are involved, as playing a role of ever-increasing importance. For example, to minimize mutual interference, the flux density of transmissions from radio transmitters must often be maintained at acceptably low radiation levels. A convenient way to meet these requirements is to spread the power spectrum of the signal before transmission and despread it after reception—the nonhostile equivalent of the military low-probability-of-intercept (LPI) signal design.

Another instance in which SS techniques are particularly useful in a nonanti-jam application is in multiple-access communications in which many users share a single communication channel. The assignment of a unique SS sequence to each user allows him or her to transmit simultaneously over the common channel with a minimum of mutual interference, simplifying the network control requirements.

Extremely accurate positioning can be computed by using signals from several satellites in synchronous and asynchronous orbits. Satellites transmitting pseudorandom noise sequences modulated onto the transmitted carrier signal provide the means for accomplishing the required range and distance determination at any point on the earth.

Finally, SS techniques can improve the reliability of transmission in frequency-selective fading and multipath environments. Spreading the bandwidth of the transmitted signal over a wide range of frequencies reduces its vulnerability to interference and often provides some diversity gain at the receiver.

At the heart of all these potential applications lies the increasing use of digital forms of modulation for transmitting information, driven by the tremendous advances made over the last decade in microelectronics. This trend no doubt will continue, and thus it should not be surprising that more and more applications for spread-spectrum techniques will continue to surface. Indeed, the state-of-the-art is advancing so rapidly (e.g., witness the recent improvements in frequency synthesizers boosting frequency hop rates from the Khops/sec to the Mhops/sec ranges over SS bandwidths in excess of a GHz) that today's primarily theoretical concepts will be realized tomorrow.

Unclassified research and developments in spread-spectrum communications have arrived at a point of maturity necessary to justify a textbook on SS communications that goes far beyond the level of those available on today's market. Such is the purpose of *Spread Spectrum Communications.* Contained within the fourteen chapters of its three volumes is an in-depth treatment of SS communications that should appeal to the specialist already familiar with the subject as well as the neophyte with little or no background in the area. The book is organized into five parts, within which the various chapters are for the most part self-contained. The exception is Chapter 3, Part 1, which deals with basic concepts and system models and serves as a basis for many of the other chapters that follow. As would be expected, the more traditional portions of the subject are treated in the first two parts, while the latter three parts deal with more specialized aspects. The authors envision that an introductory one-semester course in SS communications taught at a graduate level in a university might cover all or parts of Chapters 1, 3, 4, 5 of Part 1, Chapters 1 and 2 of Part 2, and Chapters 1 and 2 of Part 4.

In composing the technical material presented in *Spread Spectrum Communications,* the authors have intentionally avoided referring by name to specific modern SS systems that employ techniques such as those discussed in many of the chapters. Such a choice was motivated by the desire to offer a unified approach to the subject that stresses fundamental principles rather than specific applications. Nevertheless, the reader should feel confident that the broad experience of the four authors ensures that the material is practical as well as academically inspiring.

In writing a book of this magnitude, we acknowledge many whose efforts should not go unnoticed. Credit is due to Paul Green for originally suggesting

the research that uncovered the material in Chapter 2, Part 1, and to Bob Price for the tireless sleuthing which led to much of the remarkable information presented there. Chapter 5, Part 1 benefited significantly from the comments of Lloyd Welch, whose innovative research is responsible for some of the elegant sequence designs presented there. Per Kullstam helped clarify the material on DS/BPSK analysis in Chapter 1, Part 2. Paul Crepeau contributed substantially to the work on list detectors. Last but by no means least, the authors would like to thank James Springett, Gaylord Huth, and Richard Iwasaki for their contributions to much of the material presented in Chapter 4, Part 5.

Several colleagues of the authors have aided in the production of a useful book by virtue of critical reading and/or proofing. In this regard, the efforts of Paul Crepeau, Larry Hatch, Vijay Kumar, Sang Moon, Wei-Chung Peng, and Reginaldo Polazzo, Jr. are greatly appreciated.

It is often said that a book cannot be judged by its cover. The authors of *Spread Spectrum Communications* are proud to take exception to this commonly quoted cliche. For the permission to use the historically significant noise-wheel cover design (see Chapter 2, Part 1, Section 2.2.5), we gratefully acknowledge the International Telephone and Telegraph Corp.

Marvin K. Simon
Jim K. Omura
Robert A. Scholtz
Barry K. Levitt

CONTENTS

Preface xv
Preface to First Edition xvi

PART 1 INTRODUCTION TO SPREAD-SPECTRUM COMMUNICATIONS

Chapter 1 A Spread-Spectrum Overview 3
1.1 A Basis for a Jamming Game 3
1.2 Energy Allocation Strategies 6
1.3 Spread-Spectrum System Configurations and Components 9
1.4 Energy Gain Calculations for Typical Systems 17
1.5 The Advantages of Spectrum Spreading 20
1.5.1 Low Probability of Intercept (LPI) 20
1.5.2 Independent Interference Rejection and Multiple-Access Operation 25
1.5.3 High-Resolution Time-of-Arrival (TOA) Measurements 29
1.6 Design Issues 37
1.7 References 38
1.7.1 Books on Communication Theory 38
1.7.2 Books on Resolution and Ambiguity Functions 39
1.7.3 Recent Books and Proceedings on Spread-Spectrum Communications 39
1.7.4 Spread-Spectrum Tutorials and General Interest Papers 39

Chapter 2 The Historical Origins of Spread-Spectrum Communications 41
2.1 Emerging Concepts 42
2.1.1 Radar Innovations 42
2.1.2 Developments in Communication Theory 45
2.1.3 Correlator Mechanization 47
2.1.4 Protected Communications 48
2.1.5 Remote Control and Missile Guidance 58

2.2 Early Spread-Spectrum Systems 65
2.2.1 WHYN 65
2.2.2 A Note on CYTAC 71
2.2.3 Hush-Up 71
2.2.4 BLADES 73
2.2.5 Noise Wheels 78
2.2.6 The Hartwell Connection 84
2.2.7 NOMAC 87
2.2.8 F9C-A/Rake 90
2.2.9 A Note on PPM 100
2.2.10 CODORAC 100
2.2.11 *M*-Sequence Genesis 106
2.2.12 AN/ARC-50 Development at Magnavox 108
2.3 Branches on the SS Tree 111
2.3.1 Spread-Spectrum Radar 111
2.3.2 Other Early Spread-Spectrum Communication Systems 112
2.3.3 Spread-Spectrum Developments Outside the United States 121
2.4 A Viewpoint 123
2.5 References 125

Chapter 3 Basic Concepts and System Models 137
3.1 Design Approach for Anti-Jam Systems 137
3.2 Models and Fundamental Parameters 139
3.3 Jammer Waveforms 141
3.3.1 Broadband and Partial-Band Noise Jammers 141
3.3.2 CW and Multitone Jammers 143
3.3.3 Pulse Jammer 143
3.3.4 Arbitrary Jammer Power Distributions 143
3.3.5 Repeat-Back Jammers 144
3.4 Uncoded Direct-Sequence Spread Binary Phase-Shift-Keying 144
3.4.1 Constant Power Broadband Noise Jammer 147
3.4.2 Pulse Jammer 150
3.5 Coded Direct-Sequence Spread Binary Phase-Shift-Keying 153
3.5.1 Interleaver and Deinterleaver 158
3.5.2 Unknown Channel State 159
3.5.2.1 Soft Decision Decoder 160
3.5.2.2 Hard Decision Decoder 162
3.5.3 Known Channel State 165
3.5.3.1 Soft Decision Decoder 166
3.5.3.2 Hard Decision Decoder 168
3.6 Uncoded Frequency-Hopped Binary Frequency-Shift-Keying 169

此为试读,需要完整PDF请访问: www.ertongbook.com

3.6.1 Constant Power Broadband Noise Jammer 172
3.6.2 Partial-Band Noise Jammer 174
3.6.3 Multitone Jammer 176
3.7 Coded Frequency-Hopped Binary Frequency-Shift-Keying 178
3.8 Interleaver/Hop Rate Tradeoff 180
3.9 Receiver Noise Floor 180
3.10 Discussion 183
3.11 References 183
Appendix 3A: Interleaving and Deinterleaving 184

Chapter 4 General Analysis of Anti-Jam Communication Systems 189
4.1 System Model 190
4.2 Coded Bit Error Rate Bound 194
4.3 Cutoff Rates 196
4.4 Conventional Coherent BPSK 198
4.5 DS/BPSK and Pulse Jamming 204
4.6 Translation of Coded Error Bounds 205
4.7 Conventional Non-Coherent MFSK 208
4.7.1 Uncoded 208
4.7.2 Coded 213
4.8 FH/MFSK and Partial-Band Jamming 217
4.9 Diversity for FH/MFSK 227
4.10 Concatenation of Codes 235
4.10.1 Binary Super Channel 235
4.10.2 *M*-ary Super Channel 238
4.10.3 Reed-Solomon Outer Codes 238
4.11 Summary of Bit Error Bounds 246
4.11.1 DS/BPSK with Pulse Jamming 246
4.11.2 FH/MFSK with Partial-Band Noise Jamming 247
4.11.3 Coding Functions 249
4.12 References 249
Appendix 4A: Chernoff Bound 250
Appendix 4B: Factor of One-Half in Error Bounds 251
Appendix 4C: Reed-Solomon Code Performance 260

Chapter 5 Pseudonoise Generators 264
5.1 The Storage/Generation Problem 264
5.2 Linear Recursions 271
5.2.1 Fibonacci Generators 271
5.2.2 Formal Power Series and Characteristic Polynomials 273
5.2.3 Galois Generators 275
5.2.4 State Space Viewpoint 278
5.2.5 Determination of Linear Recursions from Sequence Segments 280

5.3 Memory-Efficient Linear Generators 281
5.3.1 Partial Fraction Decompositions 281
5.3.2 Maximization of Period for a Fixed Memory Size 283
5.3.3 Repeated Factors in the Characteristic Polynomial 284
5.3.4 M-Sequences 285
5.4 Statistical Properties of M-Sequences 286
5.4.1 Event Counts 287
5.4.2 The Shift-and-Add Property 288
5.4.3 Hamming Distance Properties of Derived Real-Integer Sequences 289
5.4.4 Correlation Properties of Derived Complex Roots-of-Unity Sequences 291
5.5 Galois Field Connections 297
5.5.1 Extension Field Construction 297
5.5.2 The LFSR as a Galois Field Multiplier 298
5.5.3 Determining the Period of Memory Cell Outputs 299
5.5.4 The Trace Representation of M-Sequences 301
5.5.5 A Correlation Computation 304
5.5.6 Decimations of Sequences 305
5.6 Non-Linear Feed-Forward Logic 307
5.6.1 A Powers-of-α Representation Theorem 307
5.6.2 Key's Bound on Linear Span 311
5.6.3 Difference Set Designs 315
5.6.4 GMW Sequences 317
5.7 Direct-Sequence Multiple-Access Designs 326
5.7.1 A Design Criterion 326
5.7.2 Welch's Inner Product Bound 327
5.7.3 Cross-correlation of Binary M-Sequences 329
5.7.4 Linear Designs 334
5.7.5 A Transform-Domain Design Philosophy 340
5.7.6 Bent Sequences 344
5.8 Frequency-Hopping Multiple-Access Designs 352
5.8.1 Design Criteria 352
5.8.2 A Bound on Hamming Distance 353
5.8.3 An FHMA Design Employing an M-Sequence Generator 354
5.8.4 Reed-Solomon Sequences 355
5.9 A Look at the Literature 360
5.10 References 362
Appendix 5A: Finite Field Arithmetic 367
Appendix 5B: Factorizations of 2^n-1 and Selected Primitive Polynomials 398

PART 2 CLASSICAL SPREAD-SPECTRUM COMMUNICATIONS

Chapter 1 Coherent Direct Sequence Systems 405
1.1 Direct-Sequence Spread Coherent Binary Phase-Shift Keying 407
1.2 Uncoded Bit Error Probability for Arbitrary Jammer Waveforms 409
1.2.1 Chernoff Bound 410
1.2.2 Gaussian Assumptions 411
1.3 Uncoded Bit Error Probability for Specific Jammer Waveforms 412
1.3.1 CW Jammer 414
1.3.2 Random Jammer 416
1.4 Pulse Jamming 418
1.4.1 Arbitrary Time Distribution 418
1.4.2 Worst Case Jammer 420
1.5 Standard Codes and Cutoff Rates 422
1.5.1 The Additive White Gaussian Noise Channel 422
1.5.2 Jamming Channels 424
1.6 Slow Frequency Non-Selective Fading Channels 428
1.6.1 Continuous Jammer with No Coding 428
1.6.2 Continuous Jammer with Coding—No Fading Estimate 430
1.6.3 Continuous Jammer with Coding—Fading Estimate 436
1.6.4 Pulse Jammer with No Coding 441
1.7 Slow Fading Multipath Channels 442
1.8 Other Coding Metrics for Pulse Jamming 453
1.9 Discussion 460
1.10 References 462

Chapter 2 Non-Coherent Frequency-Hopped Systems 464
2.1 Broadband Noise Jamming 471
2.2 Worst Case Jamming 475
2.2.1 Partial-Band Noise Jamming 475
2.2.2 Multitone Jamming 480
2.2.2.1 Random Jamming Tone Phase 483
2.2.2.2 Band Multitone Jamming 484
2.2.2.3 Independent Multitone Jamming 493
2.3 Coding Countermeasures 497
2.3.1 Time Diversity 497
2.3.1.1 Partial-Band Noise Jamming 500
2.3.1.2 Band Multitone Jamming 512
2.3.1.3 Independent Multitone Jamming 535

2.3.1.4 Time Diversity Overview 540
2.3.2 Coding Without Diversity 546
2.3.2.1 Convolutional Codes 547
2.3.2.2 Reed-Solomon Codes 562
2.3.2.3 Concatenated Codes 565
2.3.3 Coding With Diversity 567
2.3.3.1 Optimum Code Rates 593
2.4 Slow Fading Uniform Channels 600
2.4.1 Broadband Jamming—No Diversity 602
2.4.2 Broadband Jamming—Diversity and Coding 604
2.4.3 Partial-Band Jamming 612
2.5 Worst Noise Jammer Distribution—Slow Fading Uniform Channel 615
2.5.1 Uncoded 615
2.5.2 Diversity and Coding 619
2.6 Worst Noise Jammer Distribution—Slow Fading Nonuniform Channel 622
2.6.1 Uncoded 623
2.6.2 Diversity and Coding 626
2.7 Other Coding Metrics 630
2.7.1 Energy Quantizer 633
2.7.2 Hard Decision with One Bit Quality Measure 636
2.7.3 List Metric 641
2.7.4 Metrics for Binary Codes 652
2.8 References 660
Appendix 2A: Justification of Factor of 1/2 for FH/MFSK Signals with Diversity in Partial-Band Noise 662
Appendix 2B: Combinatorial Computation for $n = 1$ Band Multitone Jamming 664

PART 3 OTHER FREQUENCY-HOPPED SYSTEMS

Chapter 1 Coherent Modulation Techniques **669**
1.1 Performance of FH/QPSK in the Presence of Partial-Band Multitone Jamming 670
1.2 Performance of FH/QASK in the Presence of Partial-Band Multitone Jamming 680
1.3 Performance of FH/QPSK in the Presence of Partial-Band Noise Jamming 687
1.4 Performance of FH/QASK in the Presence of Partial-Band Noise Jamming 690
1.5 Performance of FH/PN/QPSK in the Presence of Partial-Band Multitone Jamming 693
1.6 Performance of FH/PN/QASK in the Presence of Partial-Band Multitone Jamming 698

1.7 Performance of FH/QPR in the Presence of Partial-Band Multitone Jamming 699
1.8 Performance of FH/QPR in the Presence of Partial-Band Multitone Jamming 710
1.9 Summary and Conclusions 713
1.10 References 713

Chapter 2 Differentially Coherent Modulation Techniques 715
2.1 Performance of FH/MDPSK in the Presence of Partial-Band Multitone Jamming 716
2.1.1 Evaluation of $Q_{2\pi n/m}$ 719
2.2 Performance of FH/MDPSK in the Presence of Partial-Band Noise Jamming 728
2.3 Performance of DQASK in the Presence of Additive White Gaussian Noise 731
2.3.1 Characterization of the Transmitted Signal 31
2.3.2 Receiver Characterization and Performance 732
2.4 Performance of FH/DQASK in the Presence of Partial-Band Multitone Jamming 739
2.5 Performance of FH/DQASK in the Presence of Partial-Band Noise Jamming 748
2.6 References 749

PART 4 SYNCHRONIZATION OF SPREAD-SPECTRUM SYSTEMS

Chapter 1 Pseudonoise Acquisition in Direct Sequence Receivers 753
1.1 Historical Survey 753
1.2 The Single Dwell Serial PN Acquisition System 765
1.2.1 Markov Chain Acquisition Model 767
1.2.2 Single Dwell Acquisition Time Performance in the Absence of Code Doppler 770
1.2.3 Single Dwell Acquisition Time Performance in the Presence of Code Doppler and Doppler Rate 777
1.2.4 Evaluation of Detection Probability P_D and False Alarm Probability P_{FA} in Terms of PN Acquisition System Parameters 781
1.2.5 Effective Probability of Detection and Timing Misalignment 785
1.2.6 Modulation Distortion Effects 786
1.2.7 Reduction in Noise Spectral Density Caused by PN Despreading 786
1.2.8 Code Doppler and Its Derivative 787
1.2.9 Probability of Acquisition for the Single Dwell System 789

1.3 The Multiple Dwell Serial PN Acquisition System 794
1.3.1 Markov Chain Acquisition Model 798
1.3.2 Multiple Dwell Acquisition Time Performance 801
1.4 A Unified Approach to Serial Search Acquisition with Fixed Dwell Times 811
1.4.1 The Flow Graph Technique 811
1.5 Rapid Acquisition Using Matched Filter Techniques 817
1.5.1 Markov Chain Acquisition Model and Acquisition Time Performance 824
1.5.2 Evaluation of Detection and False Alarm Probabilities for Correlation and Coincidence Detectors 827
1.5.2.1 Exact Results 829
1.5.2.2 Approximate Results 831
1.5.2.3 Acquisition Time Performance 833
1.6 PN Sync Search Procedures and Sweep Strategies for a Non-Uniformly Distributed Signal Location 834
1.6.1 An Example—Single Dwell Serial Acquisition with an Optimized Expanding Window Search 838
1.6.2 Application of the Circular State Diagram Approach 843
1.7 PN Synchronization Using Sequential Detection 860
1.7.1 A Brief Review of Sequential Hypothesis Testing as Applied to the Non-Coherent Detection of a Sine Wave in Gaussian Noise 864
1.7.2 The Biased Square-Law Sequential Detector 867
1.7.3 Probability of False Alarm and Average Test Duration in the Absence of Signal 868
1.7.4 Simulation Results 877
1.8 Search/Lock Strategies 885
1.8.1 Mean and Variance of the Acquisition Time 887
1.8.1.1 Evaluation of Probability Lock 890
1.8.1.2 Evaluation of Mean Dwell Time 891
1.8.2 Another Search/Lock Strategy 896
1.9 Further Discussion 898
1.10 References 899

Chapter 2 Pseudonoise Tracking in Direct Sequence Receivers 903
2.1 The Delay-Locked Loop 904
2.1.1 Mathematical Loop Model and Equation of Operation 904
2.1.2 Statistical Characterization of the Equivalent Additive Noise 909
2.1.3 Linear Analysis of DLL Tracking Performance 911
2.2 The Tau-Dither Loop 915

此为试读,需要完整PDF请访问: www.ertongbook.com