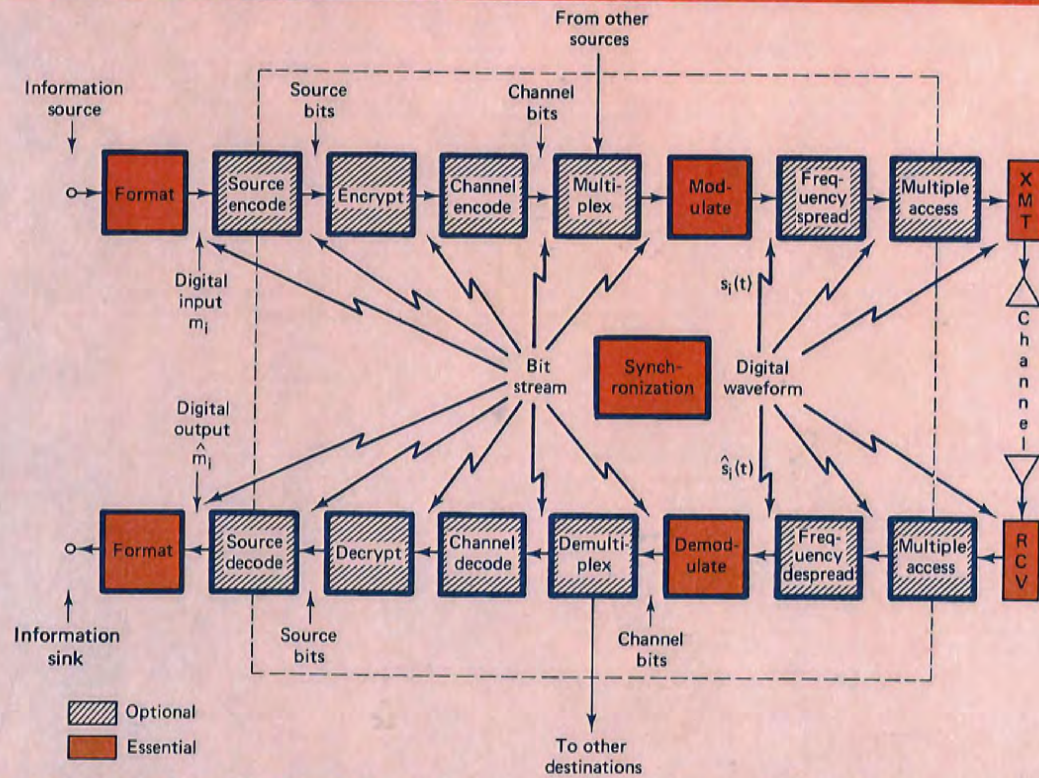


BERNARD SKLAR  
**DIGITAL COMMUNICATIONS**  
 Fundamentals and Applications



Find authenticated court documents without watermarks at [docketalarm.com](http://docketalarm.com).

**DOCKET**  
 ALARM

# DIGITAL COMMUNICATIONS

## Fundamentals and Applications

**BERNARD SKLAR**

*The Aerospace Corporation, El Segundo, California  
and  
University of California, Los Angeles*



P T R Prentice Hall  
Englewood Cliffs, New Jersey 07632

---

Editorial/production supervision and  
interior design: Reynold Rieger  
Cover design: Wanda Lubelska Design  
Manufacturing buyers: Gordon Osbourne and Paula Benevento



© 1988 by P T R Prentice-Hall, Inc.  
A Simon & Schuster Company  
Englewood Cliffs, New Jersey 07632

All rights reserved. No part of this book may be  
reproduced, in any form or by any means,  
without permission in writing from the publisher.

Printed in the United States of America

10

ISBN 0-13-211939-0 025

Prentice-Hall International (UK) Limited, *London*  
Prentice-Hall of Australia Pty. Limited, *Sydney*  
Prentice-Hall Canada Inc., *Toronto*  
Prentice-Hall Hispanoamericana, S.A., *Mexico*  
Prentice-Hall of India Private Limited, *New Delhi*  
Prentice-Hall of Japan, Inc., *Tokyo*  
Simon & Schuster Asia Pte. Ltd., *Singapore*  
Editora Prentice-Hall do Brasil, Ltda., *Rio de Janeiro*



# Contents

PREFACE xxi

**1 SIGNALS AND SPECTRA** **1**

- 1.1 Digital Communication Signal Processing, 3
  - 1.1.1 *Why Digital?*, 3
  - 1.1.2 *Typical Block Diagram and Transformations*, 4
  - 1.1.3 *Basic Digital Communication Nomenclature*, 9
  - 1.1.4 *Digital versus Analog Performance Criteria*, 11
- 1.2 Classification of Signals, 11
  - 1.2.1 *Deterministic and Random Signals*, 11
  - 1.2.2 *Periodic and Nonperiodic Signals*, 12
  - 1.2.3 *Analog and Discrete Signals*, 12
  - 1.2.4 *Energy and Power Signals*, 12
  - 1.2.5 *The Unit Impulse Function*, 13
- 1.3 Spectral Density, 14
  - 1.3.1 *Energy Spectral Density*, 14
  - 1.3.2 *Power Spectral Density*, 15
- 1.4 Autocorrelation, 17
  - 1.4.1 *Autocorrelation of an Energy Signal*, 17
  - 1.4.2 *Autocorrelation of a Periodic (Power) Signal*, 17
- 1.5 Random Signals, 18
  - 1.5.1 *Random Variables*, 18
  - 1.5.2 *Random Processes*, 20

vii

- 1.6.3 *Distortionless Transmission*, 32
- 1.6.4 *Signals, Circuits, and Spectra*, 38
- 1.7 **Bandwidth of Digital Data**, 41
  - 1.7.1 *Baseband versus Bandpass*, 41
  - 1.7.2 *The Bandwidth Dilemma*, 43
- 1.8 **Conclusion**, 46
- References, 46
- Problems, 47

## 2 **FORMATTING AND BASEBAND TRANSMISSION**

51

- 2.1 **Baseband Systems**, 54
- 2.2 **Formatting Textual Data (Character Coding)**, 55
- 2.3 **Messages, Characters, and Symbols**, 55
  - 2.3.1 *Example of Messages, Characters, and Symbols*, 55
- 2.4 **Formatting Analog Information**, 59
  - 2.4.1 *The Sampling Theorem*, 59
  - 2.4.2 *Aliasing*, 66
  - 2.4.3 *Signal Interface for a Digital System*, 69
- 2.5 **Sources of Corruption**, 70
  - 2.5.1 *Sampling and Quantizing Effects*, 70
  - 2.5.2 *Channel Effects*, 71
  - 2.5.3 *Signal-to-Noise Ratio for Quantized Pulses*, 72
- 2.6 **Pulse Code Modulation**, 73
- 2.7 **Uniform and Nonuniform Quantization**, 74
  - 2.7.1 *Statistics of Speech Amplitudes*, 74
  - 2.7.2 *Nonuniform Quantization*, 76
  - 2.7.3 *Companding Characteristics*, 77
- 2.8 **Baseband Transmission**, 78
  - 2.8.1 *Waveform Representation of Binary Digits*, 78
  - 2.8.2 *PCM Waveform Types*, 78
  - 2.8.3 *Spectral Attributes of PCM Waveforms*, 82
- 2.9 **Detection of Binary Signals in Gaussian Noise**, 83
  - 2.9.1 *Maximum Likelihood Receiver Structure*, 85
  - 2.9.2 *The Matched Filter*, 88
  - 2.9.3 *Correlation Realization of the Matched Filter*, 90
  - 2.9.4 *Application of the Matched Filter*, 91
  - 2.9.5 *Error Probability Performance of Binary Signaling*, 92

viii

Contents

# Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

## Real-Time Litigation Alerts



Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

## Advanced Docket Research



With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

## Analytics At Your Fingertips



Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

## API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

## LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

## FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

## E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.