

Communication Systems Analysis and Design

Harold P.E. Stern Samy A. Mahmoud

adition is trade. Bandles is UNAUTHORIZED.

COMMUNICATION SYSTEMS Analysis and Design

SEMINAR LIBRARY

University of Alabama, Tuscaloosa
Samy A. Mahmoud
Carleton University, Ottawa
Lee Elliott Stern
Graphic Developer



Contents

Preface Acknowledg	#2. Building the Optimist Receiver (The Metabord 2016) Retestor) 32 545 years to reduction of the Control Street and Albertain Street	xiii xvii
Chapter 1	Introduction 1	
1.1	Components of a Communication System 1	
1.2	An Overview of Trade-Offs in Communication System Design Problems 5	4
Chapter 2	Frequency Domain Analysis 6	
2.1	Why Study Frequency Domain Analysis? 6	
2.2	The Fourier Series 13	
	2.2.1 Trigonometric Form of the Fourier Series 13	
6.3	2.2.2 Other Forms of the Fourier Series 18	
2.3	Representing Power in the Frequency Domain 38	
	2.3.1 The One-Sided Average Normalized Power Spectrum 4 2.3.2 Formally Defining the Term "Bandwidth" 48	11
		8
2.4	The Fourier Transform 52	
2.5	Normalized Energy Spectral Density 60	
2.6	Properties of the Fourier Transform 65	
2.7	Using the Unit Impulse Function to Represent Discrete Frequency	
	Components as Densities 68	
	Problems 69 to its in both assessmed later of a resignation	
States 3	Digital Baseband Modulation Techniques 75	
	Goals in Communication System Design 75 Baseband Modulation Using Rectangular Pulses and Binary Pulse Bilitude Modulation 76	
		-22

	Pulse Shaping to Improve Spectral Efficiency 89
3.3	3.3.1 The Sinc-Shaped Pulse 89
	Dulse (Damped Sine Simple)
	Pulse) 101 Pulse) 111
3.4	Building a Baseband Transmitter 111
	Problems 115
	Receiver Design (and Stochastic Mathematics, Part I) 123
Chapter 4	Receiver Design (and Stochastic Peceiver 122
4.1	Developing a Simple Pulse Amplitude Modulation Receiver 123
	4.1.2 Stochastic Mathematics—Part I (Random
	4.1.2 Examining Thermal Noise 132
	Deskability Density Function 137
	the state of the Lungaceion for Floudulity of Little
4.2	- The Marchell I like of Southernion
	Receiver) 149
	421 Basic Structure for the Optimal Receiver 149
	4.2.2 Implications of Employing Optimum Processing 133
	4.2.3 A Graphical Interpretation of Probability of Bit Error for the
	Optimal Receiver 156
	4.2.4 Designing the Correlation Receiver for More General
	Signals 162
4.3	Synchronization 172
	4.3.1 Basic Structure of Continuous-Time Phase Locked
	Loops 173 TA TIAMOU VOICE TO THE TOTAL TOT
	4.3.2 Analysis of the PLL with Linearized Dynamics 173
	4.3.3 Frequency Synthesizers 178
	4.3.4 Timing Recovery 181
	4.3.5 Further Reading on Synchronization 189
4.4	Equalization 190
	4.4.1 Intersymbol Interference 192
	4.4.2 Linear Transversal Equalizers 196
	4.4.3 Least-Mean-Square Equalizers 198
	4.4.4 Other Types of Equalizers 199
45	4.4.5 Further Reading on Equalization 199 Multi-Level PAM (Mary PAM) 200
4.5	District (M-ary PAINI) 200
	DESCRIPTION OF THE PROPERTY OF
Ch	
Chapter 5	Digital Bandpass Modulation and Demodulation Techniques
	(and Stochastic Mathematics, Part II) 211
5.1	Rinary Ameliand Otto
5.2	Other Binary Bandpass Modules 7
and the second	January Michigan Lechniques 240
	Diffaty Frequency Shift Keying 210
	and I have Shill Keving 221
	5.2.3 Calculating Average Normalized Power Spectral Density

300.5	3 Coherent Demodulation of Bandpass Signals 225
	5.3.1 Developing a Coherent PSK Receiver 227
	5.3.2 Developing a Coherent ASK Receiver 230
	5.3.3 Developing a Coherent FSK Receiver 232
	5.3.4 Comparing Coherent PSK, FSK, and ASK 235
5.	4 Stochastic Mathematics—Part II (Random Processes) 236
	5.4.1 Random Processes 238
	5.4.2 The Wiener-Khintchine Theorem 245
	5.4.3 Ergodicity 252
Referen	5 Noncoherent Receivers for ASK and FSK 253
	5.5.1 The Envelope Detector 254
	5.5.2 Noncoherent Demodulation of ASK 255
	5.5.3 Noncoherent Demodulation of FSK 255
	5.5.4 Performance of Noncoherent ASK and FSK Receivers 256
5.0	
	5.6.1 Demodulation of Binary DPSK 268
ppression, a	5.6.2 Probability of Bit Error for a DPSK Receiver 270
5.7	
5.8	THE RESIDENCE AND ADDRESS OF THE PARTY OF TH
	5.8.1 Quaternary Phase Shift Keying 274
	5.8.2 Differential Quaternary Phase Shift Keying 284
	5.8.3 M-ary Phase Shift Keying 286
	5.8.4 M-ary Frequency Shift Keying 292
	5.8.5 Multiparameter M-ary Bandpass Signaling 298
	Problems 301
	2.5.1 Static Dictionary Encoding 439
Chapter 6	Analog Modulation and Demodulation 306
6.1	Transmitting an Amplitude Modulated Signal 306
6.2	Coherent Demodulation of AM Signals 309
6.3	Noncoherent Demodulation of AM Signals 315
	Single Sideband and Vestigial Sideband AM systems 326
6.4	Frequency Modulation and Phase Modulation 334
6.5	Generating and Demodulating FM and PM Signals 343
6.6	Generating and Demodalating
	6.6.1 FM and PM Modulators 343
	6.6.2 FM and PM Demodulators 345
	6.6.3 Noise in FM and PM Systems 347
6.7	A Comparison of Analog Modulation Techniques 355
0.7	Problems 357 - Colubed him would be 201

Chaper 7	Multiplexing Techniques 362
Address of the Local Division in which the Local Division in the L	The STOCK SHIRINGER SOME
CT 7.1	Time Division Multiplexing 364
7.2	Frequency Division Multiplexing 368
	Code Division Multiplexing and Spread Spectram 370
7.3	man C County Spectrum 1/1
	7.3.1 Direct Sequence Spread Spectrum 381
	73.2 Frequency-Hopping Spread Spectrum

	Analog-to-Line 390 cionals 392 397
Chapter 8	and Quantizing Analog Signals Sampling
8.1 S	Analog-to-Long 390 Sampling and Quantizing 390 Sampling and Quantizing Analog Signals 392 Sampling Baseband Analog Signals 399 Sampling Baseband Analog Signals 399
	8.1.1 Sampling Consideration Analog Signals
	Analog-to-Long 390 Sampling and Quantizing 390 Sampling and Quantizing Analog Signals Sampling Baseband Analog Signals Sampling Bandpass Analog Signals Practical Considerations in Signals Sampling Bandpass Analog Signals Sampling Bandpass Analog A00 Sampling Bandpass Analog A00 Sampling Bandpass Analog Signals
	8.1.2 Sampling Bandpass 400 8.1.3 Sampling Bandpass 400 8.1.4 The Quantizing Process 8.1.4 The Quantizing Process Since Process 400 Since Proces
	8.1.4 The Coded Modulis Variable Stop
8.2	Differential Pulse and Continuously
8.3	Delta Modulation 415
0.5	Modulation 411 Modulation 411 Stone Delta Modulation Modulation 411 Stone Delta Modulation
	8.3.1 Delta Module Variable Slope and Digital-to-
	Modulation 411 Modulation 411 8.3.1 Delta Modulation 5lope Delta Modulation 415 8.3.2 Continuously Variable Slope Delta Modulation 415 Further Reading on Analog-to-Digital and Digital-to-Analog Further Reading on Analog-to-Digital and Digital-to-Analog Further Reading on Analog-to-Digital and Digital-to-Analog
0.4	Further Reading
8.4	Conversion 417
	Problems 417 Data Compression, and
	Theory, Data Cont
	- Amentals of Information
Chapter 9	Problems 417 Problems 417 Fundamentals of Information Theory, Data Compression, and 421 Fundamentals of Information Theory, Data Compression 421
	Image Company and Information
0.1	Fundamentals of Information 421 Image Compression Information Content, Entropy, and Information Rate of Independent Sources 421 Variable-Length, Self-Punctuating Coding for Data Compression 424 Variable-Length, Self-Punctuating Coding for Data Compression 426 Variable-Length, Self-Punctuating Coding for Data Compression 427
9.1	Sources 421 Coding for Data 426
141	Variable-Length, Self-Punctuation Tree Diagram
9.2	Variable-Length, Self-Punctuating Coding 426 9.2.1 Prefix Coding and the Tree Diagram 6.2.1 Coding 431
	9.2.1 Prefix Coding 431 9.2.2 Huffman Coding 431 439
298	9.2.2 Huffman Coding Sources with Dependent Messages Sources with Dependent Messages 439 439 The of Dynamic Dictionary
9.3	Sources with Dependent Message 9.3.1 Static Dictionary Encoding 9.3.1 Static Dictionary Encoding 9.3.2 LZW Compression—an Example of Dynamic Dictionary 9.3.2 LZW Compression—an Example of Dynamic Dictionary
	9.3.1 Static Diction—an Example of Dynamics of Lympic of
	Encoding
	Still-Image Compression 444
9.4	94.1 Facsimile 444
	9.4.1 Facsimile Gray Scale Images
	The transport the LOCI miles
	9.4.3 Color Images (the base) 450
9.5	
	Problems 454
	450
	10 Basics of Error Control Coding 458
Chapter	The state of the s
10.1	Channel Capacity 460 Channel Capacity 460 Operators 461
10.2	Field Theory and Modulo-2 Operators 401
10.0	10.2.1 Galois Field of Order 2 401
	10.2.1 Matrix Representation and Manipulation 463
10.2	Hamming Codes 464
10.3	1 Interpretation of Error Control Coding 4/4
10.4	
10.5	and the contract of the contra
	10.5.1 Cyclic Reduitedines circum
	10.5.2 Bose Chaudhuri Hocquenghem Codes 487

10.6	Hybrid	FEC/ARQ Codes 488	
10.7	Correct	ing Burst Errors 489	
	10.7.1	Interleaving 489	
	10.7.2	Reed-Solomon Codes 490	
10.8	Convol	utional Codes and Viterbi Decoding	490
	10.8.1		
	10.8.2		
	10.8.3		497
	Probles	The state of the s	
	10.8.1 10.8.2 10.8.3	Convolutional Encoding 490 Creating a Trellis 496 Decoding and the Viterbi Algorithm	

References 509

Answers to Selected Problems 515

Index 519