

CONTENTS

CHAPTER ONE

A Measure of Information

1.1	Introduction	1
1.2	Axioms for the Uncertainty Measure	5
1.3	Three Interpretations of the Uncertainty Function	12
1.4	Properties of the Uncertainty Function; Joint and Conditional Uncertainty ..	16
1.5	The Measure of Information	21
1.6	Notes and Remarks	24

CHAPTER TWO

Noiseless Coding

2.1	Introduction	27
2.2	The Problem of Unique Decipherability	28
2.3	Necessary and Sufficient Conditions for the Existence of Instantaneous Codes	33
2.4	Extension of the Condition $\sum_{i=1}^M D^{-n_i} \leq 1$ to Uniquely Decipherable Codes ..	35
2.5	The Noiseless Coding Theorem	36
2.6	Construction of Optimal Codes	40
2.7	Notes and Remarks	43

CHAPTER THREE

The Discrete Memoryless Channel

3.1	Models for Communication Channels	46
3.2	The Information Processed by a Channel; Channel Capacity; Classification of Channels	49
3.3	Calculation of Channel Capacity	53
3.4	Decoding Schemes; the Ideal Observer	60
3.5	The Fundamental Theorem	63
3.6	Exponential Error Bounds	77
3.7	The Weak Converse to the Fundamental Theorem	80
3.8	Notes and Remarks	83

CHAPTER FOUR

Error Correcting Codes

4.1	Introduction; Minimum Distance Principle	87
4.2	Relation between Distance and Error Correcting Properties of Codes; the Hamming Bound	89

x	CONTENTS	
4.3	Parity Check Coding	91
4.4	The Application of Group Theory to Parity Check Coding	95
4.5	Upper and Lower Bounds on the Error Correcting Ability of Parity Check Codes	105
4.6	Parity Check Codes Are Adequate	110
4.7	Precise Error Bounds for General Binary Codes	113
4.8	The Strong Converse for the Binary Symmetric Channel	124
4.9	Non-Binary Coding	126
4.10	Notes and Remarks	127
CHAPTER FIVE		
Further Theory of Error Correcting Codes		
5.1	Feedback Shift Registers and Cyclic Codes	134
5.2	General Properties of Binary Matrices and Their Cycle Sets	138
5.3	Properties of Cyclic Codes	147
5.4	Bose-Chaudhuri-Hocquenghem Codes	156
5.5	Single Error Correcting Cyclic Codes; Automatic Decoding	161
5.6	Notes and Remarks	163
CHAPTER SIX		
Information Sources		
6.1	Introduction	169
6.2	A Mathematical Model for an Information Source	169
6.3	Introduction to the Theory of Finite Markov Chains	172
6.4	Information Sources; Uncertainty of a Source	184
6.5	Order of a Source; Approximation of a General Information Source by a Source of Finite Order	189
6.6	The Asymptotic Equipartition Property	195
6.7	Notes and Remarks	206
CHAPTER SEVEN		
Channels with Memory		
7.1	Introduction	211
7.2	The Finite-State Channel	215
7.3	The Coding Theorem for Finite State Regular Channels	219
7.4	The Capacity of a General Discrete Channel; Comparison of the Weak and Strong Converses	223
7.5	Notes and Remarks	227
CHAPTER EIGHT		
Continuous Channels		
8.1	Introduction	230
8.2	The Time-Discrete Gaussian Channel	231
8.3	Uncertainty in the Continuous Case	236
8.4	The Converse to the Coding Theorem for the Time-Discrete Gaussian Channel	243
8.5	The Time-Continuous Gaussian Channel	250

	CONTENTS	xi
8.6	Band-Limited Channels	256
8.7	Notes and Remarks	260
Appendix		
1.	Compact and Symmetric Operators on $L_2[a, b]$	262
2.	Integral Operators	269
3.	The Karhunen-Loève Theorem	275
4.	Further Results Concerning Integral Operators Determined by a Covariance Function	281
Tables of Values of $-\log_2 p$ and $-p \log_2 p$		291
Solutions to Problems		293
References		331
Index		335