Chapter 1 Introduction 1

1.1 Historical Background 1

1.2 Applications 4

1.3 Primary Resources and Operational Requirements 13

1.4 Underpinning Theories of Communication Systems 14

Chapter 2 Fourier Representation of Signals and Systems 18

2.1 The Fourier Transform 19

2.2 Properties of the Fourier Transform 25

2.3 The Inverse Relationship Between Time and Frequency 39

2.4 Dirac Delta Function 42

2.5 Fourier Transforms of Periodic Signals 50

2.6 Transmission of Signals Through Linear Systems: Convolution Revisited 52

2.7 Ideal Low-pass Filters 60

2.8 Correlation and Spectral Density: Energy Signals 70

2.9 Power Spectral Density 79

2.10 Numerical Computation of the Fourier Transform 81

Chapter 3 Amplitude Modulation 100

3.1 Amplitude Modulation 101

3.2 Virtues, Limitations, and Modifications of Amplitude Modulation 113

3.3 Double Sideband-Suppressed Carrier Modulation 114

3.4 Costas Receiver 120

3.5 Quadrature-Carrier Multiplexing 121

3.6 Single-Sideband Modulation 123

3.7 Vestigial Sideband Modulation 130

3.8 Baseband Representation of Modulated Waves and Band-Pass Filters 137

3.9 Theme Examples 142

Chapter 4 Angle Modulation 152

4.1 Basic Definitions 153

4.2 Properties of Angle-Modulated Waves 154

4.3 Relationship between PM and FM Waves 159

4.4 Narrow-Band Frequency Modulation 160

4.5 Wide-Band Frequency Modulation 164

4.6 Transmission Bandwidth of FM Waves 170

4.7 Generation of FM Waves 172

4.8 Demodulation of FM Signals 174

4.9 Theme Example: FM Stereo Multiplexing 182

Chapter 5 Pulse Modulation: Transition from Analog to Digital Communications 190

5.1 Sampling Process 191

5.2 Pulse-Amplitude Modulation 198

5.3 Pulse-Position Modulation 202

5.4 Completing the Transition from Analog to Digital 203

5.5 Quantization Process 205

5.6 Pulse-Code Modulation 206

5.8 Differential Pulse-Code Modulation 216

5.9 Line Codes 219

5.10 Theme Examples 220 {TDM]

Chapter 6 Baseband Data Transmission 231

6.1 Baseband Transmission of Digital Data 232

6.2 The Intersymbol Interference Problem 233

6.3 The Nyquist Channel 235

6.4 Raised-Cosine Pulse Spectrum 238

6.5 Baseband Transmission of M-ary Data 245

6.6 The Eye Pattern 246

6.7 Computer Experiment: Eye Diagrams for Binary and Quaternary Systems 249

Chapter 7 Digital Band-Pass Modulation Techniques 262

7.1 Some Preliminaries 262

7.2 Binary Amplitude-Shift Keying 265

7.3 Phase-Shift Keying 270

7.4 Frequency-Shift Keying 281

7.5 Summary of Three Binary Signaling Schemes 289

7.6 Noncoherent Digital Modulation Schemes 291

7.7 M-ary Digital Modulation Schemes 295

7.8 Mapping of Digitally Modulated Waveforms onto Constellations of Signal Points 299

7.9 Theme Examples 302 [OFDM & LTE]

Chapter 9 Noise in Analog Communications 364

9.1 Noise in Communication Systems 365

9.2 Signal-to-Noise Ratios 366

9.3 Band-Pass Receiver Structures 369

9.4 Noise in Linear Receivers Using Coherent Detection 370

9.5 Noise in AM Receivers Using Envelope Detection 373

9.6 Noise in SSB Receivers 377

9.7 Detection of Frequency Modulation (FM) 380

9.8 FM Pre-emphasis and De-emphasis 387

9.9 Summary and Discussion 390

Additional Problems 391

Advanced Problems 392

Computer Experiments 393

Chapter 10 Noise in Digital Communications 394

10.1 Bit Error Rate 395

10.2 Detection of a Single Pulse in Noise 396

10.3 Optimum Detection of Binary PAM in Noise 399

10.4 Optimum Detection of BPSK 405

10.5 Detection of QPSK and QAM in Noise 408

10.6 Optimum Detection of Binary FSK 414

10.8 Summary of Digital Performance 418

Chapter 11 System and Noise Calculations 437

11.1 Electrical Noise 438

11.2 Noise Figure 442

11.3 Equivalent Noise Temperature 443

11.4 Cascade Connection of Two-Port Networks 445

11.5 Free-Space Link Calculations 446