

CHAPTER 1

THE DEVELOPMENT OF DIGITAL NETWORKS

- 1.1 Introduction to Digital Telecommunications
 - 1.1.1 The Digital Revolution
 - 1.1.2 Digital Network Development
 - 1.1.3 Pulse Code Modulation Fundamentals
 - 1.1.4 Growth in Data Transmission
- 1.2 The Components of a Communication System
 - 1.2.1 System Functions
 - 1.2.2 Comparison of Analogue and Digital Systems
- 1.3 Digital Data Transmission
 - 1.3.1 Voice band Data Transmission
 - 1.3.2 Public Data Networks
 - 1.3.3 Non-switched Data Networks
 - 1.3.4 Packet Switched Data Networks
 - 1.3.5 Local Area Networks
- 1.4 Integrated Services and Hierarchies
 - 1.4.1 PCM Bit Rates and Hierarchies
 - 1.4.2 Bit Rates for other Services
- 1.5 Scope of this text

CHAPTER 2

BASEBAND DIGITAL TRANSMISSION SIGNALS

- 2.1 Introduction
 - 2.1.1 A Digital Transmission System
 - 2.1.2 Baseband Signals
- 2.2 Baseband Line Transmission Systems
- 2.3 Algebraic Representation of Line Signals
- 2.4 Encoding and Pulse Shaping
 - 2.4.1 System Elements
 - 2.4.2 Alternate-mark-inversion (AMI) Code
- 2.5 Line Waveforms

- 2.6 Line Code Selection
 - 2.6.1 Desirable Code Characteristics
 - 2.6.2 AMI Code Properties
 - 2.6.3 Manchester Code (twinned binary, split phase)
 - 2.6.4 Differential Diphas Code
- 2.7 Methods for Calculating Frequency Spectra
 - 2.7.1 Spectra of Periodic Signals
 - 2.7.2 Spectra of Aperiodic Signals
 - 2.7.3 Spectra of Random Waveforms
- 2.8 Power Spectral Density of Line Codes
- 2.9 Other Ternary Line Codes
 - 2.9.1 High Density Bipolar (HDBn) Codes
 - 2.9.2 4B3T Codes
 - 2.9.3 5B4T, 7B5T, 8B6T, and 10B7T Codes

CHAPTER 3

INTERSYMBOL INTERFERENCE AND PULSE SHAPING

- 3.1 Introduction
- 3.2 Nyquist Pulse Shaping
 - 3.2.1 Maximum Rate Pulses
 - 3.2.2 Symbol Packing Rate
 - 3.2.3 Nyquist Vestigial Symmetry Criterion for Zero ISI
 - 3.2.4 Raised Cosine Spectrum for Zero ISI
 - 3.2.5 Pulse Shaping Circuits
- 3.3 Multilevel Signalling
- 3.4 Correlative (Partial Response) Signalling
 - 3.4.1 Duobinary Scheme
 - 3.4.2 Generalised Correlative (partial response) Encoding
 - 3.4.3 Modified duobinary (Class 4 Partial Response) scheme

CHAPTER 4

SIGNAL REGENERATION

- 4.1 Introduction
- 4.2 Regenerative Repeaters
 - 4.2.1 Functions
 - 4.2.2 Clock Recovery
 - 4.2.3 Sampling and Decision Circuits
- 4.3 Equalisers
 - 4.3.1 Functions
 - 4.3.2 Typical Equaliser Characteristics
 - 4.3.3 Transversal Equalisers
 - 4.3.4 Automatic Equalisers
 - 4.3.5 Computer Simulation
- 4.4 Bit-error Rate Calculations
 - 4.4.1 Mathematical Models
 - 4.4.2 Probability of error-wideband Gaussian noise case
 - 4.4.3 Allocation of Transmit and Receive Gaussian Filtering

CHAPTER 5

MEASUREMENT TECHNIQUES

- 5.1 Introduction
- 5.2 Eye Diagrams
 - 5.2.1 Measurement Procedures
 - 5.2.2 Important Features of Eye Patterns
 - 5.2.3 Effects of Intersymbol Interference
 - 5.2.4 Effects of Noise and Crosstalk
- 5.3 Near End Crosstalk Noise Figure
 - 5.3.1 Regenerator Performance Measurement
 - 5.3.2 Input Signal to NEXT Noise Ratio
- 5.4 Pseudorandom Binary Test Signals
 - 5.4.1 Introduction
 - 5.4.2 Searching for a Random Sequence
 - 5.4.3 Feedback Shift Register Generators
 - 5.4.4 Properties of Pseudorandom Binary Signals
 - 5.4.5 Applications of Pseudorandom Sequences

- 5.5 Error Rate Measurements
 - 5.5.1 Bit-error Rates
 - 5.5.2 Error-free Seconds
- 5.6 Regenerator Fault Location Tests
 - 5.6.1 Triples Test Signal
 - 5.6.2 Fault Location Procedure

CHAPTER 6

DIGITAL RADIO SYSTEMS

- 6.1 Introduction
 - 6.1.1 Historical Developments
 - 6.1.2 Digital Versus Analogue Radio
- 6.2 Typical Digital Radio Systems
 - 6.2.1 Digital Radio Equipment
 - 6.2.2 Transmission Capacities and Frequency Bands
 - 6.2.3 Typical Equipment Characteristics
 - 6.2.4 Performance Objectives
- 6.3 Modulation Methods
 - 6.3.1 Spectral Efficiency
 - 6.3.2 Choice of Modulation Type
 - 6.3.3 PSK (Phase-Shift-Keyed) Modulation Schemes
 - 6.3.4 FSK (Frequency-Shift-Keying) Modulation
 - 6.3.5 16 QAM (Quadrature-Amplitude) Modulation
 - 6.3.6 Quadrature Partial Response Signalling (QPRS)
 - 6.3.7 Minimum Shift Keying (MSK) Systems
- 6.4 Detection
 - 6.4.1 Optimum Detector for Binary PSK, FSK or ASK in Gaussian
 - 6.4.2 Coherent Detector for QAM and M-PSK Signals
 - 6.4.3 Optimum Detectors for Channels with ISI-Viterbi Algorithms
 - 6.4.4 Non-coherent Detectors
 - 6.4.5 Bit-error Rate Performance
- 6.5 Radio Link System Design
 - 6.5.1 Free Space Calculations for Single Hops
 - 6.5.2 Flat Fade Margin
 - 6.5.3 Percentage Outage Prediction - Vigant's Formula
 - 6.5.4 Frequency Selective Fading - Rummler's Model
 - 6.5.5 Intersymbol Interference due to Frequency Selective Fading

- 6.5.6 Space Diversity
- 6.5.7 Adaptive Equalisation
- 6.6 Hybrid Radio Systems
 - 6.6.1 Data In Voice (DIV) Systems
 - 6.6.2 Data Above Voice (DAV) and Data Above Video (DAVID) Systems
 - 6.6.3 Data Over Voice (DOV) Systems
 - 6.6.4 Data Under Voice (DUV) Systems
- 6.7 Digital Concentrator Subscriber Radio Systems

CHAPTER 7

COMPUTER NETWORKS

- 7.1 Introduction
- 7.2 Classification of Computer Networks
- 7.3 Computer Network Structures
- 7.4 ISO Model for Open Systems Interconnection (OSI)
 - 7.4.1 Physical Level Protocols
 - 7.4.2 Data Link Layer
 - 7.4.3 Error Checking in the BISYNC Protocol
 - 7.4.4 Other Control Characters and Segments
 - 7.4.5 Transparency
 - 7.4.6 Multipoint Transmission
 - 7.4.7 Synchronization
 - 7.4.8 Byte Count Protocols
 - 7.4.9 Bit-oriented Data Link Control Protocols
- 7.5 Network Layer
 - 7.5.1 X.25 Recommendations
 - 7.5.2 X.75 Recommendations
- 7.6 Higher Layers
- 7.7 Multiple Access Techniques
 - 7.7.1 Random Aloha
 - 7.7.2 Slotted
 - 7.7.3 Reservation
- 7.8 Local Area Networks
- 7.9 Network Design Fundamentals

CHAPTER 8

ERROR CONTROL IN DIGITAL NETWORKS

- 8.1 Introduction
- 8.2 Errors and Erasures
- 8.3 Error Detection Using Block Codes
 - 8.3.1 Single Bit Parity Detection
 - 8.3.2 Weight Distribution of a Code
 - 8.3.3 Error Detection Reliability of the Single-Parity Code
 - 8.3.4 Linear Block Codes for Error Detection
 - 8.3.5 Minimum Distance of a Code
- 8.4 Cyclic Codes for Error Detection
 - 8.4.1 Polynomial Representation
 - 8.4.2 Generator Polynomial
 - 8.4.3 Generation of Parity (encoding)
 - 8.4.4 Encoder for Rec. X.25 Frame Check Sequence
 - 8.4.5 Decoding for Error Detection
 - 8.4.6 Error Detection for the CCITT Rec. X.25 Code
 - 8.4.7 Variable Block Lengths - Shortened Cyclic Codes
 - 8.4.8 Probability of Un-Detected Error
- 8.5 Automatic-Repeat-Request (ARQ) Systems
 - 8.5.1 ARQ Procedures
 - 8.5.2 Throughput of Go-Back-N ARQ
 - 8.5.3 Other ARQ Procedures
- 8.6 Hybrid ARQ Schemes
 - 8.6.1 Parity Retransmission ARQ Strategy
 - 8.6.2 Retransmission Protocols
 - 8.6.3 Choice of Error Correction Code
 - 8.6.4 Throughput Analysis

CHAPTER 9

DIGITAL SWITCHING

- 9.1 Digital Switching
 - 9.1.1 Local Networks
 - 9.1.2 Concentrators
 - 9.1.3 Digital Group Selector
 - 9.1.4 Advantages of Concentrators with Centralised Exchanges
 - 9.1.5 Digital PCM Switching Techniques
 - 9.1.6 Exchange Congestion

- 9.2 Network Synchronization
 - 9.2.1 Synchronization Requirements - Slips
 - 9.2.2 Causes of Slips
 - 9.2.3 Approaches to Network Synchronization
 - 9.2.4 Plesiochronous Networks
 - 9.2.5 Master-Slave Synchronization
 - 9.2.6 Mutual Synchronization
 - 9.2.7 Comparison of Synchronization Methods
- 9.3 Frame Synchronization
 - 9.3.1 Introduction
 - 9.3.2 Frame Alignment Systems
 - 9.3.3 State Diagrams and Design Principles
 - 9.3.4 Choice of Frame Alignment Signal

CHAPTER 10

DIGITAL CODING OF VOICE AND TELEVISION SIGNALS

- 10.1 Impairments Due to Sampling
 - 10.1.1 Flat-top Samples
 - 10.1.2 Anti-aliasing Filter
 - 10.1.3 Reconstruction Filter
 - 10.1.4 Switched Capacitor Filter Methods
- 10.2 Digital Encoding of Analogue Signals
 - 10.2.1 Coding Methods
 - 10.2.2 Distortion Criteria
- 10.3 PCM System Performance
 - 10.3.1 Quantization Noise
 - 10.3.2 Companding Techniques
 - 10.3.3 CCITT Standards for Quantization Noise
- 10.4 Coding Techniques for Reduced Bit Rates
 - 10.4.1 Principles of Data Compression
 - 10.4.2 Adaptive Pulse Code Modulation (APCM)
 - 10.4.3 Differential Pulse Code Modulation (DPCM)
 - 10.4.4 Delta Modulation (DM)
 - 10.4.5 Adaptive Differential Pulse Code Modulation (ADPCM)
 - 10.4.6 Adaptive Predictive Coding (APC)

BASIC DIGITAL TRANSMISSION SYSTEM THEORY
COURSE OUTLINE

1. Linear Systems Dr K.C. Ng (Monash) 7 Lectures

Time domain and frequency domain, analysis of linear systems, including convolution and Fourier Transform. Application to Digital Transmission Systems.

2. Random Processes Dr K.K. Pang (Monash) 7 Lectures

Basic probability theory, random time processes including auto-correlation and power spectrum. Response of transmission systems to random inputs.

3. Digital Transmission Dr D.B. Keogh (Monash) 9 Lectures

Fundamentals.

Linear representation of digital signals. Bandlimiting, inter-symbol interference. Nyquist pulse shaping, roll-off. Average power spectral density of digital signals. Error probability formula for multilevel digital signals.

Line Coding.

Rationale. Examples - conditional diphase, AMI and HDB3. Physical description, average power spectral density.

Modulated digital signals.

Rationale. Examples, linear - digital Am (DSBAM, DSBAMSC, WAM, PM: VSBAM, SSBAM). Examples, nonlinear - digital FM. Time and frequency domain representations. Phase jitter tolerance. Application of baseband error probability formula to modulated digital signals.

4. Applications Dr A. Jennings and Messrs A. Martin & G. Nicholson
(Telecom) 5 Lectures

Baseband transmission in pair cable.

Effect of impulse noise and compatibility with other services on a 4800 bit/s DNN signal. 2048 kbit/s line systems - crosstalk into similar systems, noise figure.

Data-in-Voice (DIV) performance.

2048 kbit/s DIV transmission in 2 or 3 contiguous super-groups between Melbourne and Sydney.

Digital Radio.

Example based on 140 Mbit/s digital radio system.

Introduction single hop system design for flat fading, effect of frequency selective fading.

Optical Fibre Systems

Example based on 140 Mbit/s system.

Noise processes, regenerator section length design.

5. Summing up and Review

General course revision and course evaluation.