BECE306L - Digital Communication Systems
Fall Intra (2023-24)

Course Instructor

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Guidelines to be followed:

- Be on time for the class as per the schedule.
- Always have a **dedicated notebook** and your own **calculator** to solve the numerical problems during the class hours.
- Stick to the **deadlines** for the Assignments, Quizzes and other assessment activities.
- Be attentive and ask your doubts then and there during the class hours.
- Feel free to share your views towards the course/topic and the instructor regarding the content delivery.
- Let it be more of a discussion and Happy learning for all..!!

General course information:

- Prerequisite – BECE206L/Analog Communication System
- Important concepts will be explained qualitatively using real-life examples
- However, as an engineering student, extensive use of mathematics is necessary for accurate system modelling and analysis
- Theory – 3 credits - 3 hrs per week – Totally 45 hrs
- Lab – 1 credit – 2 hrs per week

Course objectives:

- To understand the transmitter and receiver blocks of various waveform coding techniques.
- To analyze various line coding techniques in time and frequency domains.
- To identify the role of baseband, bandpass formats and information theory for effective transmission of signals, combat ISI and to increase the reliability of transmission.
- To understand the principles and importance of spread spectrum and multiple access in the context of communication.

Course outcomes:

- Comprehend the sampling and quantization process to recover the original signal.
- Analyse the performance of various waveform and Line coding techniques.
- Design the various baseband pulses for ISI free transmission over finite bandwidth channels.
- Examine the BER and bandwidth efficiency of the Bandpass modulation techniques.
- Analyse the digital communication system with spread spectrum modulation.
- Infer the elements of information theory.

Syllabus

- **Module:1** **Sampling Process**
- **Module:2** **Waveform Coding Techniques**
- **Module:3** **Line Codes**
- **Module:4** **Baseband System**
- **Module:5** **Bandpass System**
- **Module:6** **Spread Spectrum Techniques and Multiple Access Techniques**
- **Module:7** **Introduction to Information Theory**

Text/Reference Books

- Simon Haykin, Digital Communications, 2017, 1st Edition, John Wiley, India.
- John G. Proakis, Masoud Salehi, Digital Communication, 2018, 5th Edition (Indian edition), Mc Graw Hill Education, India.
- Bernard Sklar and Fredric J. Harris, Digital Communications: Fundamentals and Applications, 2020, 3rd Edition, Pearson , UK.
- B P Lathi, Zhi Ding, Modern Digital And Analog Communication Systems, 2017, 4th Edition, Oxford university Press, India

Evaluation Metrics

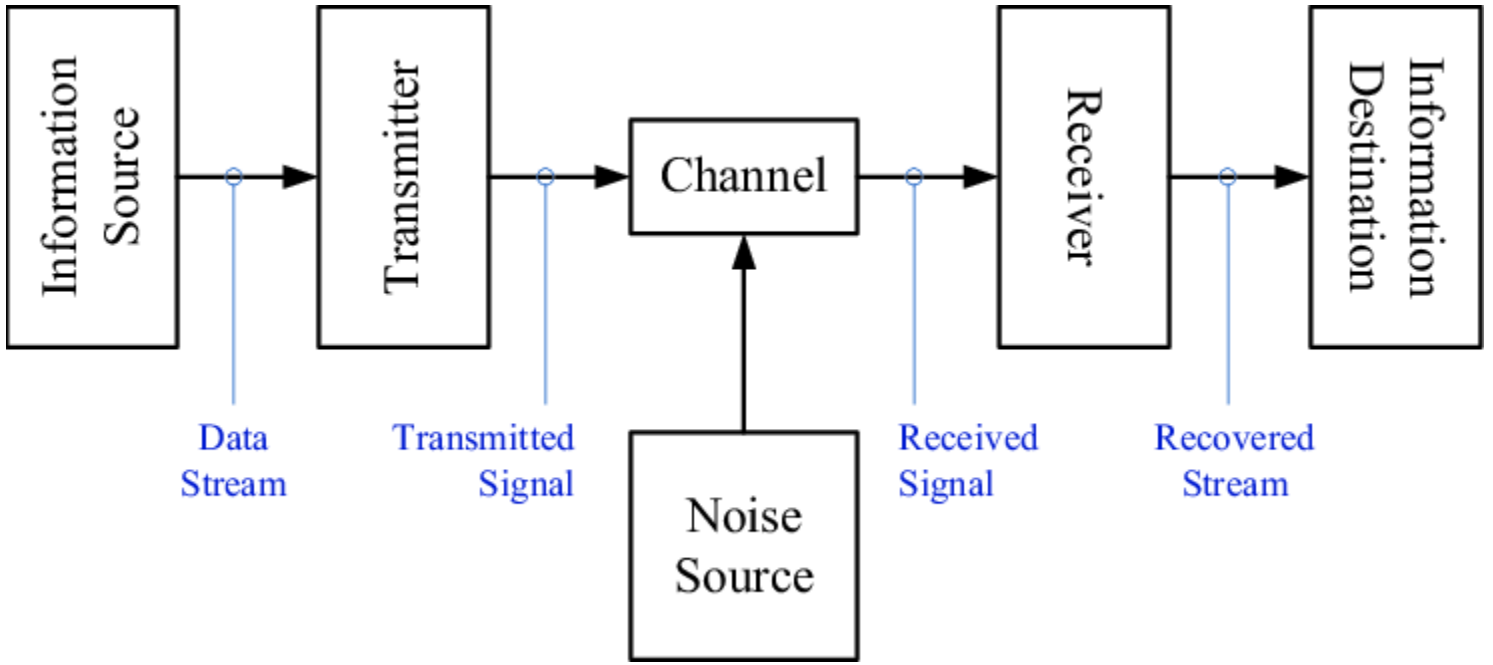
- DA – 1 – 10 marks
- Quiz – 1 - 10 marks (After CAT-1)
- Quiz – 2 - 10 marks (After CAT-2)
- CAT – 1 – 15 marks
- CAT – 2 – 15 marks
- FAT – 40 marks

Introduction

- Communication has been one of the deepest needs of the human race throughout recorded history.
- It is essential to forming social unions, to educating the young, and to expressing a myriad of emotions and needs.
- Good communication is **central** to a civilized society.
- The communication that occurs in our day-to-day life is in the form of signals.
- These signals, such as sound signals, generally, are analog in nature.
- When the communication needs to be established over a distance, then the analog signals are sent using different techniques for effective transmission.

Introduction

- Main purpose of communication is to transfer information from a source to a recipient via a channel or medium.
- Basic block diagram of a communication system:



Introduction

Basic Description

- **Source:** analog or digital
- **Transmitter:** transducer, amplifier, modulator, oscillator, power amp, antenna
- **Channel:** e.g. cable, optical fibre, free space
- **Receiver:** antenna, amplifier, demodulator, oscillator, power amplifier, transducer
- **Recipient:** e.g. person, (loud) speaker, computer

Introduction

- **Types of information**

  Voice,data,video,music,email etc.

- **Types of communication systems**

  Public Switched Telephone Network

  (voice,fax,modem) Satellite systems

  Radio,TV

  broadcasting Cellular

  phones

  Computer networks (LANs,WANs,WLANs)

Introduction

- Communication system converts information into electrical electromagnetic/optical signals appropriate for the transmission medium.
- Analog systems convert analog message into signals that can propagate through the channel.
- Digital systems convert bits(digits, symbols) into signals
  - Computers naturally generate information as characters/bits
  - Most information can be converted into bits
  - Analog signals converted to bits by sampling and quantizing (A/D conversion)

History of communication system

The Necessity of Digitization

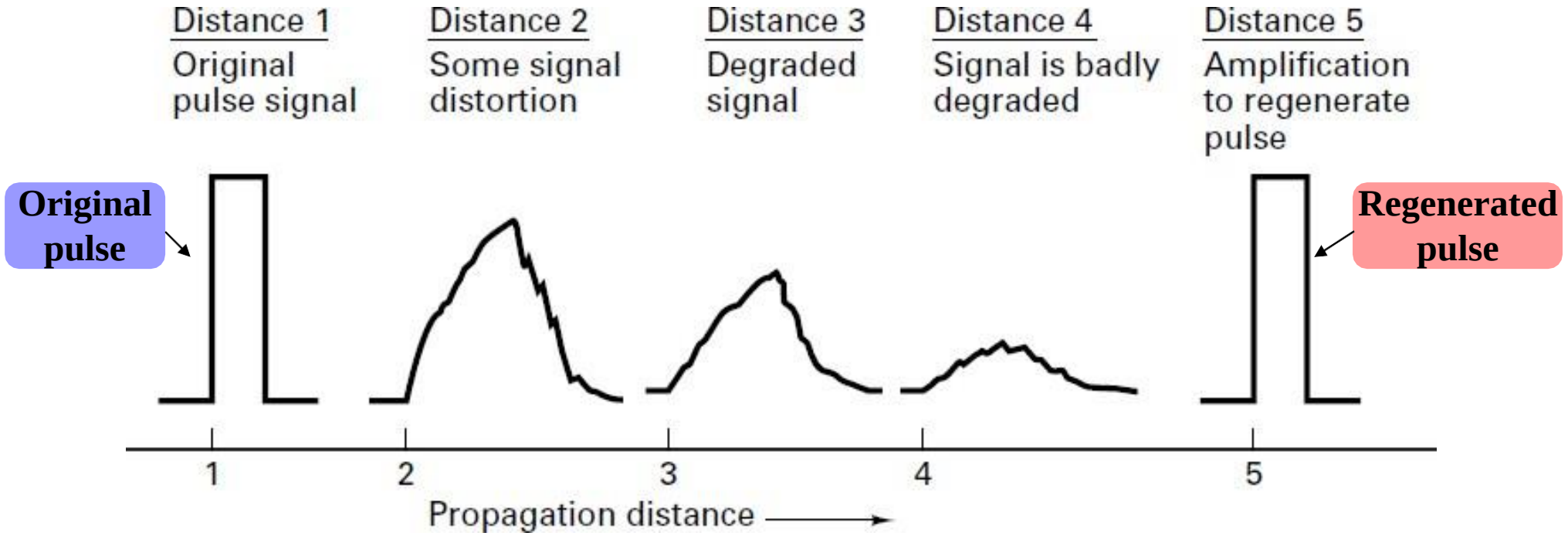
- Why are communication systems, military and commercial alike, "going digital"? There are many reasons,
- Analog signals suffer from many losses such as distortion, interference, and other losses including security breach.
- In order to overcome these problems, the signals are digitized using different techniques.

Analog Signal

Digital Signal

The Necessity of Digitization

- The primary advantage is the ease with which digital signals, compared with analog signals, are **regenerated**.



Analog versus Digital

Figure 2-1
A simple example of an analog waveform

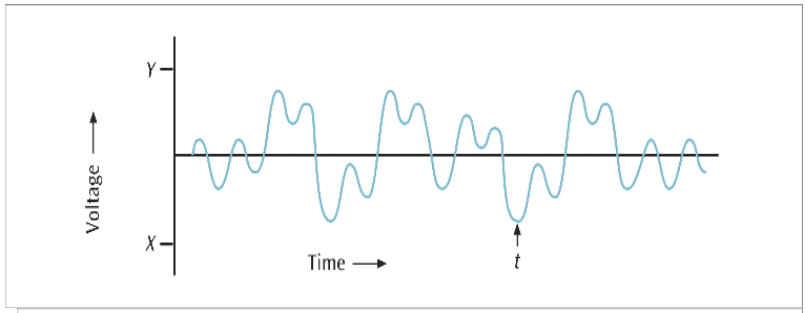


Figure 2-2
The waveform of a symphonic overture with noise

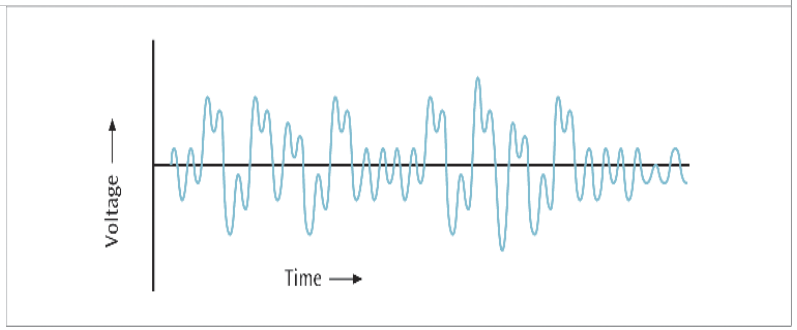


Figure 2-3
A simple example of a digital waveform

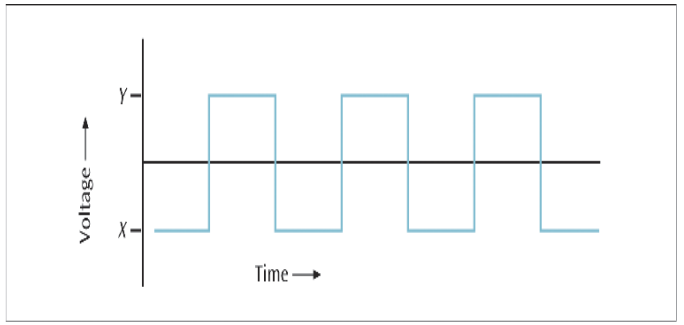


Figure 2-4
A digital signal with some noise introduced

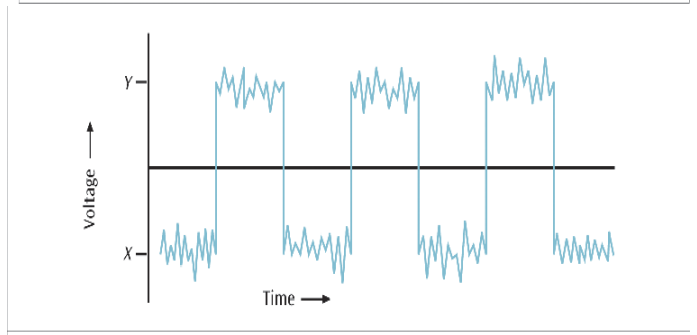
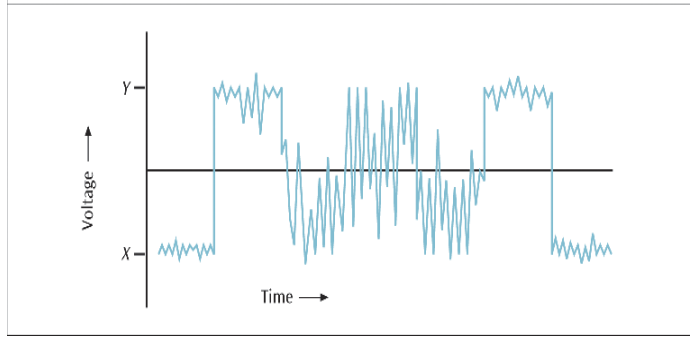


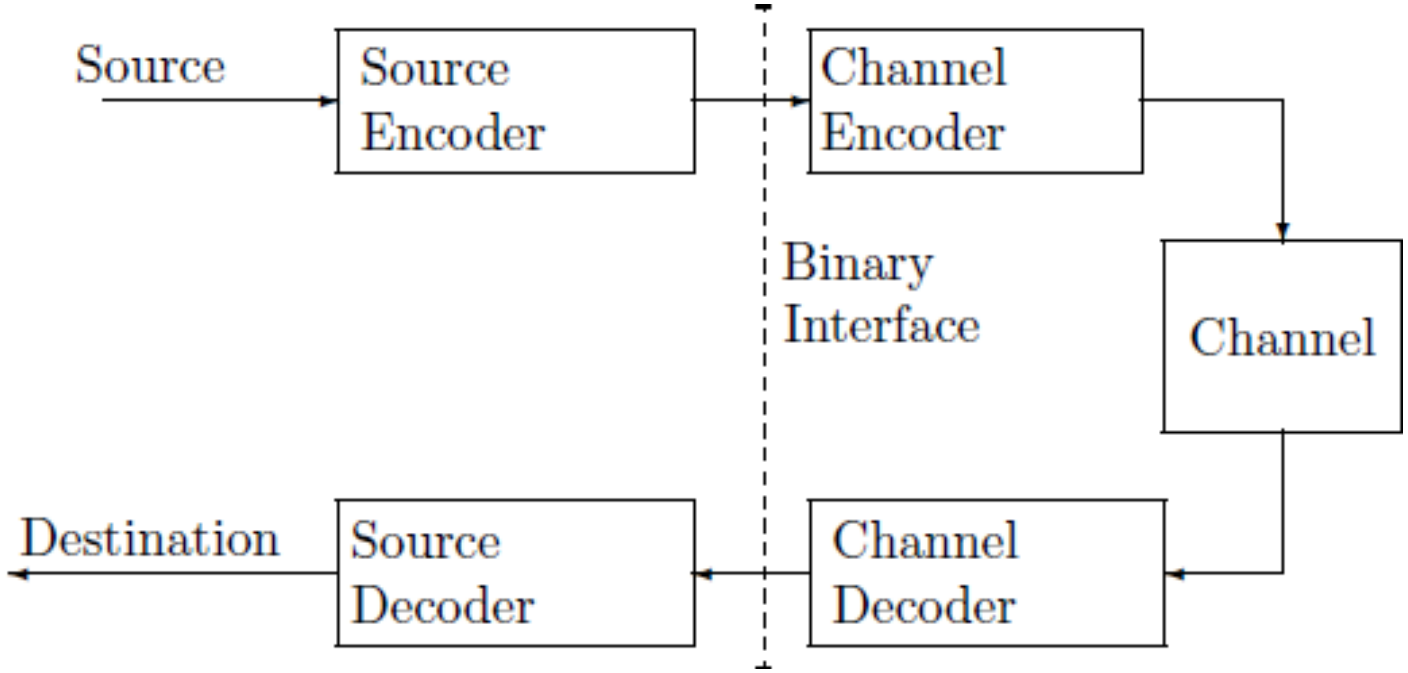
Figure 2-5
A digital waveform with noise so great that you can no longer recognize the original waveform



- Harder to separate noise from an analog signal than from a digital signal
- If there is too much noise ➔ cannot discern a high voltage from a low voltage

Digital Communication System

- By definition, are communication systems that uses digital sequence as an interface between the source and the channel input and similarly between the channel output and final destination.

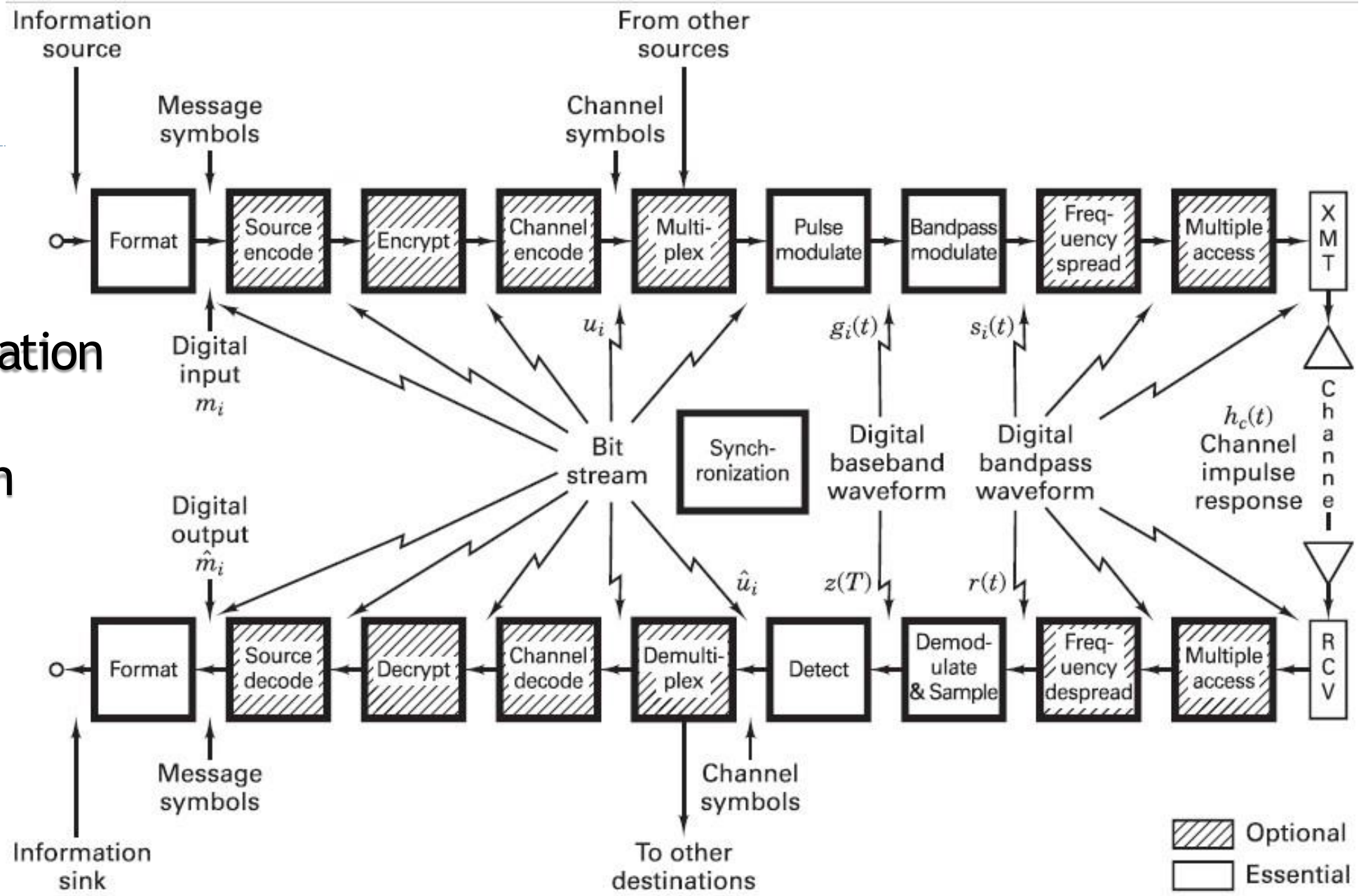


Digital Communication System

- There are a number of reasons why digital communication systems are now standard, briefly they are as follows:

1. Digital hardware has become so cheap, reliable, and miniaturized, that digital interfaces are eminently practical.
2. A standardized binary interface between source and channel simplifies implementation and understanding.
   - Since source coding/decoding can be done independently of the channel.
   - Similarly, channel coding/decoding can be done independently of the source.
3. A standardized binary interface between source and channel simplifies networking.

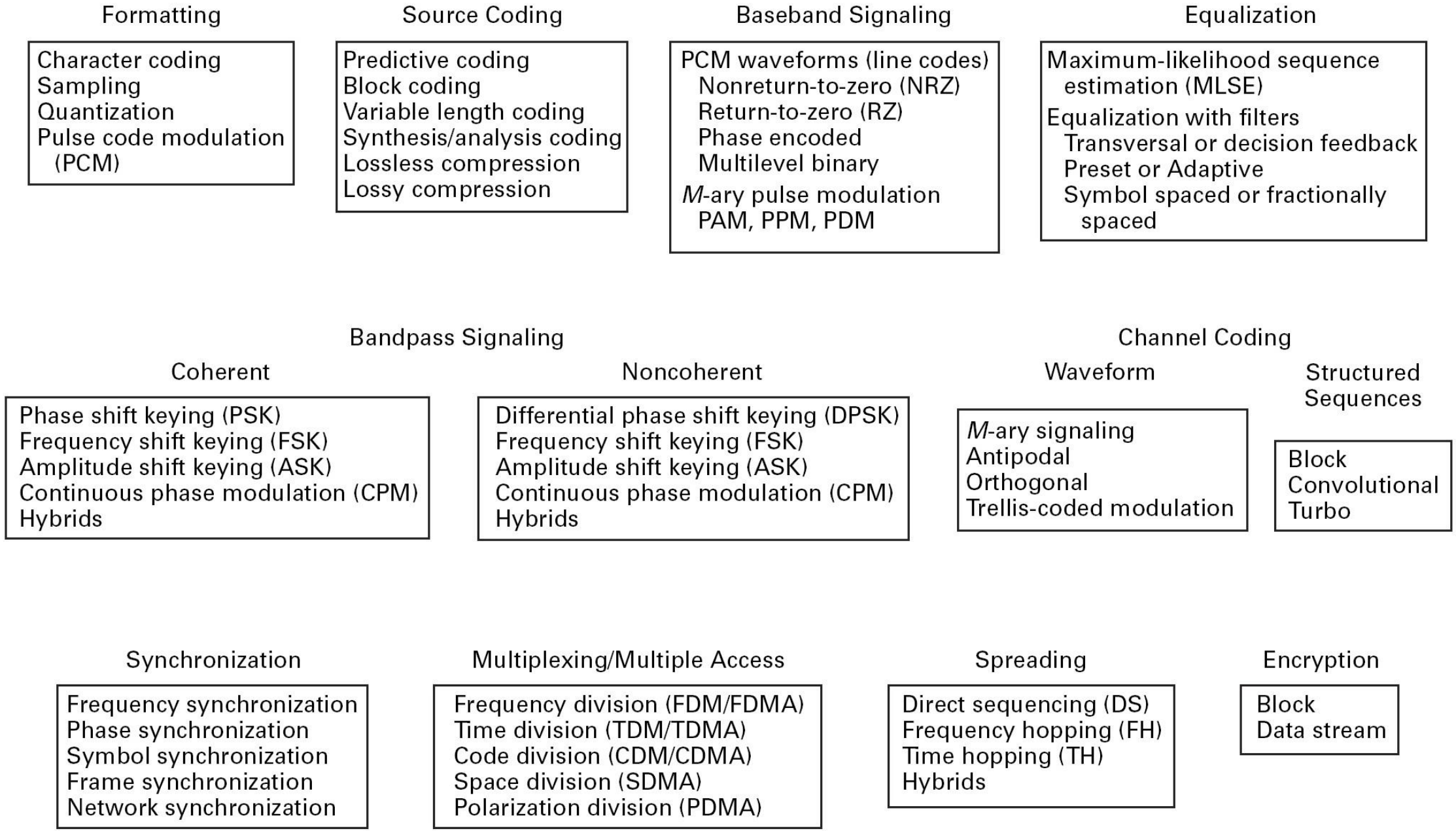
Digital Communication Systems: Block Diagram



Digital Communication System

- The basic signal processing functions, which may be viewed as transformations, classified into the following nine groups:

1. Formatting and source coding
2. Baseband signalling
3. Bandpass signalling
4. Equalization
5. Channel coding
6. Multiplexing and multiple access
7. Spreading
8. Encryption
9. Synchronization


Formatting
Character coding
Sampling
Quantization
Pulse code modulation (PCM)
Source Coding
Predictive coding
Block coding
Variable length coding
Synthesis/analysis coding
Lossless compression
Lossy compression
Baseband Signaling
PCM waveforms (line codes)
Nonreturn-to-zero (NRZ)
Return-to-zero (RZ)
Phase encoded
Multilevel binary
M-ary pulse modulation
PAM, PPM, PDM
Equalization
Maximum-likelihood sequence estimation (MLSE)
Equalization with filters
Transversal or decision feedback
Preset or Adaptive
Symbol spaced or fractionally spaced
Bandpass Signaling
Coherent
Phase shift keying (PSK)
Frequency shift keying (FSK)
Amplitude shift keying (ASK)
Continuous phase modulation (CPM)
Hybrids
Noncoherent
Differential phase shift keying (DPSK)
Frequency shift keying (FSK)
Amplitude shift keying (ASK)
Continuous phase modulation (CPM)
Hybrids
Channel Coding
Waveform
M-ary signaling
Antipodal
Orthogonal
Trellis-coded modulation
Structured Sequences
Block
Convolutional
Turbo
Synchronization
Frequency synchronization
Phase synchronization
Symbol synchronization
Frame synchronization
Network synchronization
Multiplexing/Multiple Access
Frequency division (FDM/FDMA)
Time division (TDM/TDMA)
Code division (CDM/CDMA)
Space division (SDMA)
Polarization division (PDMA)
Spreading
Direct sequencing (DS)
Frequency hopping (FH)
Time hopping (TH)
Hybrids
Encryption
Block
Data stream

Advantages of Digital Communication

- The effect of distortion, noise, and interference is much less in digital signals as they are less affected.
- Digital circuits are more reliable.
- Digital circuits are easy to design and cheaper than analog circuits.
- The hardware implementation in digital circuits, is more flexible than analog.
- The occurrence of cross-talk is very rare in digital communication.
- The signal is un-altered as the pulse needs a high disturbance to alter its properties, which is very difficult.
- Signal processing functions such as encryption and compression are employed in digital circuits to maintain the secrecy of the information.

Advantages of Digital Communication

- The probability of error occurrence is reduced by employing error detecting and error correcting codes.
- Spread spectrum technique is used to avoid signal jamming.
- Combining digital signals using Time Division Multiplexing TDM is easier than combining analog signals using Frequency Division Multiplexing FDM.
- The configuring process of digital signals is easier than analog signals.
- Digital signals can be saved and retrieved more conveniently than analog signals.
- Many of the digital circuits have almost common encoding techniques and hence similar devices can be used for a number of purposes.
- The capacity of the channel is effectively utilized by digital signals.