IT321
Communication Technology
Part 1: Introduction

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Fall 2023

Acknowledgement: *This presentation contains some figures and text from Data Communications and Networks book by W. Stallings*

Introduction

- Communication – Basic process of exchanging information from one location (source) to destination (receiving end).

- Refers to the process of sending, receiving and processing of information/signal/input from one point to another point.

Goal of communication systems

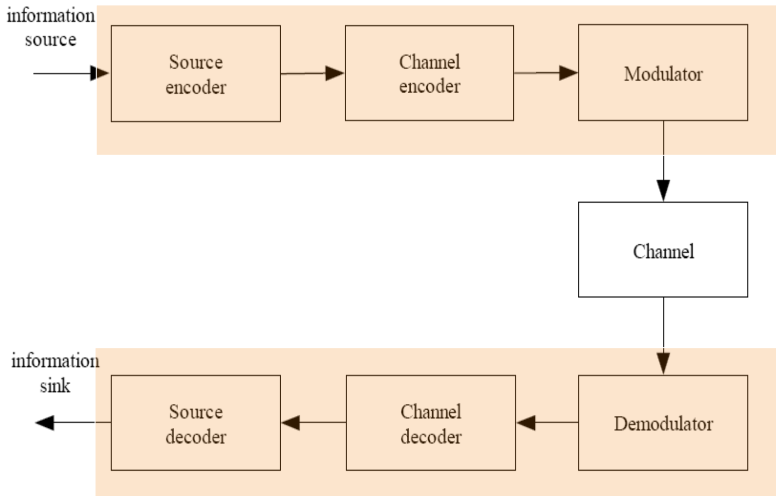
- Transmit and Receive information under noisy channel (e.g., AWGN) with:
  - small power (energy)
    - SNR
  - small error
    - Probability of Error

Communication Systems Components

- Any communication system consists of three basic blocks:
  - Transmitter
  - Receiver
  - Communication Channel

- A transmitter prepares the data (information) to be transmitted in the appropriate format in order to be transmitted over the communication channel.

Communication System Components (cont.)



Communication System Components (cont.)

- Information Source
  - Generates the message(s) . Examples are voice, television picture, computer key board, etc..
  - If the message is not electrical, a transducer is used to convert it into an electrical signal.
  - Source can be analog or digital.

Communication System Components (cont.)

- Source encoder/decoder

- The source encoder maps the signal produced by the source into a digital form (for both analog and digital).
- The mapping is done so as to remove redundancy in the output signal and also to represent the original signal as efficiency as possible (using as few bits as possible).
- The mapping must be such that an inverse operation (source decoding) can be easily done.
- Primary objective of source encoding/decoding is to reduce bandwidth, while maintaining adequate signal fidelity.

Communication System Components (cont.)

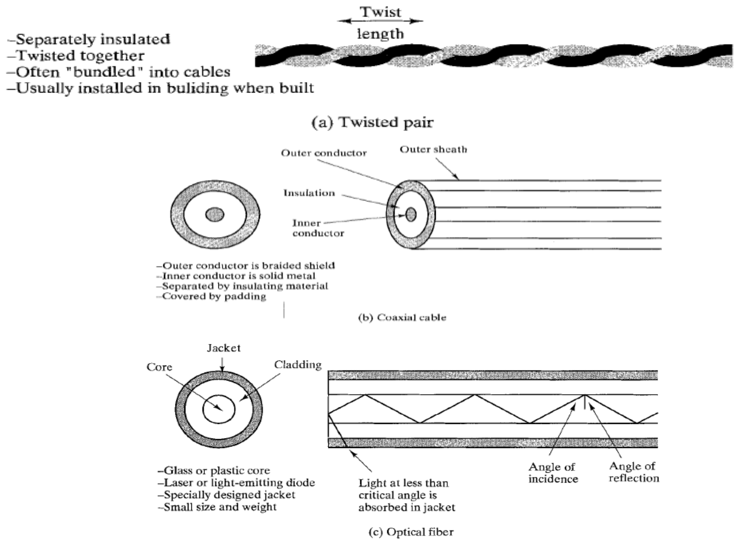
- Channel encoder/decoder

- Maps the input digital signal into another digital signal in such a way that the noise will be minimized.
- Channel coding thus provides for reliable communication over a noisy channel.
- Redundancy is introduced at the channel encoder and exploited at the decoder to correct errors.

- Modulator

- Modulation provides for efficient transmission of the signal over channel.
- Most modulation schemes impress the information on either the amplitude, phase or frequency of a sinusoid.

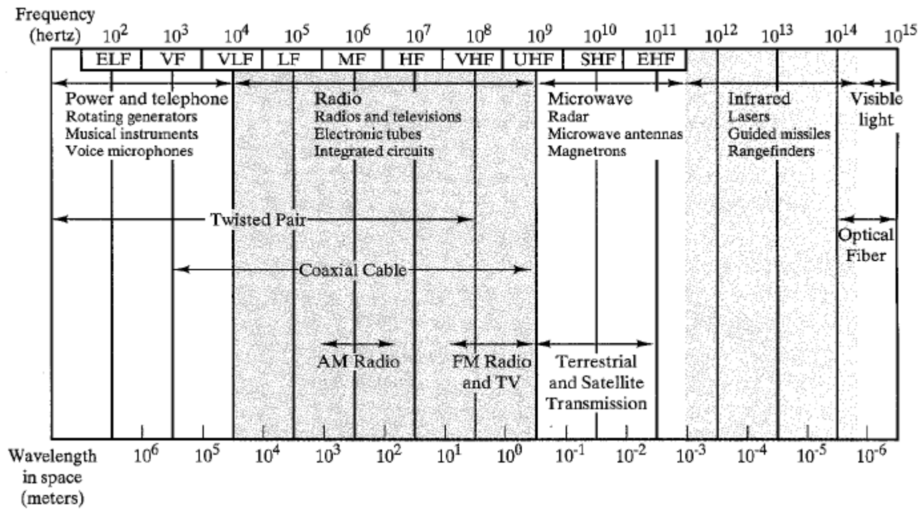
Examples of Wired Comm. Channels



Why Different Types of Comm. Systems?

- There are several factors that give rise to the need for different types of communication systems:
  - The nature of the communication channel (undersea communication requires optical fiber cables)
  - The nature of the application (mobile applications needs wireless systems)
  - Required level of quality (performance and quality of the received signal)
  - Cost

Spectrum of Telecomm Systems

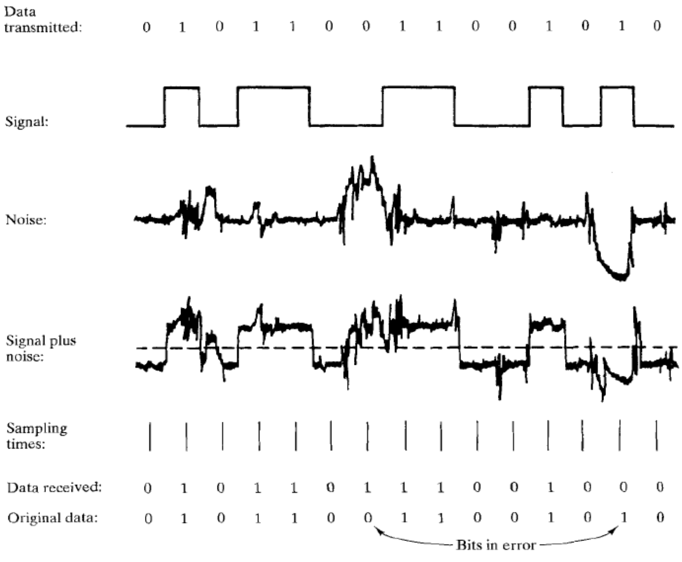


Problems that Face Comm. Systems

- Any communication system can be subject to three main sources of problems:

1. Noise: undesired effect from the communication environment. Usually, it is not under our control (your system has to deal with it).
2. Interference: due to superposition of two or more signals. May result from bad design of communication systems (interference of voice channels in telephone systems, for example)
3. Jamming: intentional interference that aims at destroying the quality of the transmitted signal to prevent transmission.

Problems that Face Comm. Systems *(cont.)*



Effect of noise on a digital signal

Problems that Face Comm. Systems *(cont.)*

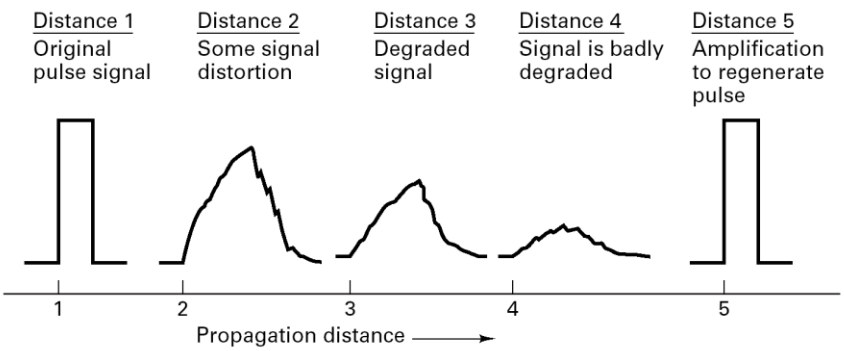


Figure 1.1 Pulse degradation and regeneration.

Data versus Signal

- Differentiate between two terms: data (information) and signal.
- **Data (information):** are generated by the application and need to be transmitted to some receiver.
- **Signal:** is the representation of the data in the communication system.
- Data are generated from the source (application) and signals are generated from the transmitter of the communication system we build.
- Speaking in a microphone: data (information) is what I say, whereas signal is what moves inside the wire of the microphone (electricity).

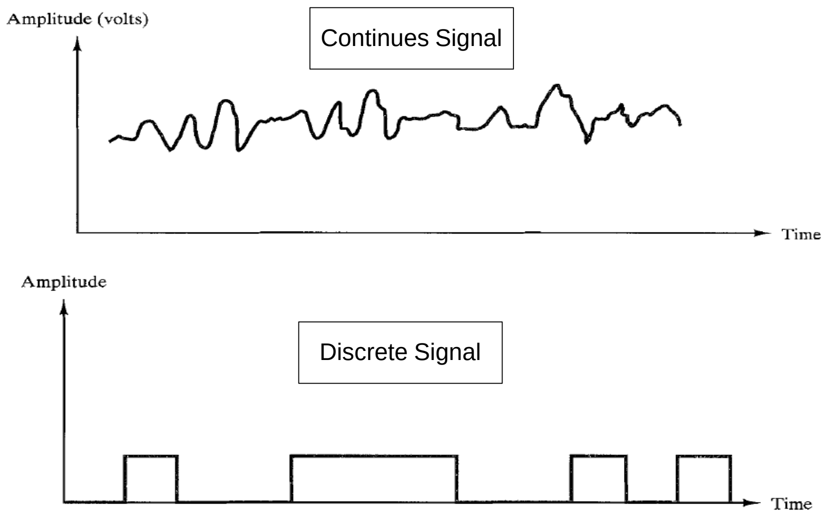
Types of Data and Signal

- Depending on the application nature, we have four possible combinations of data and signals:
  - Analog Data: Analog Signal
  - Analog Data: Digital Signal
  - Digital Data: Analog Signal
  - Digital Data: Digital Signal
- We will study these combinations during this course.
- Since any communication system deals with signals, we first need to understand the nature and types of signals.

Signal Representation in the Time Domain

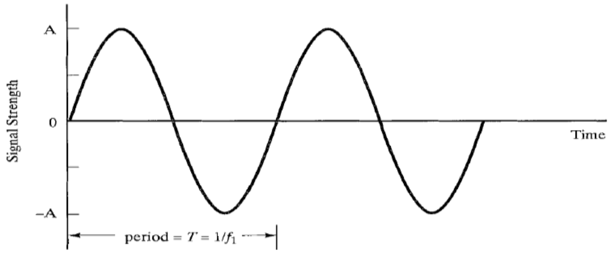
- Viewed as a function of time, an electromagnetic signal can be either continuous or discrete.
- A continuous signal is one in which the signal intensity varies in a smooth fashion over time.
- A discrete signal is one in which the signal intensity maintains a constant level for some period of time and then changes to another constant level.

Signal Representation in the Time Domain *(cont.)*

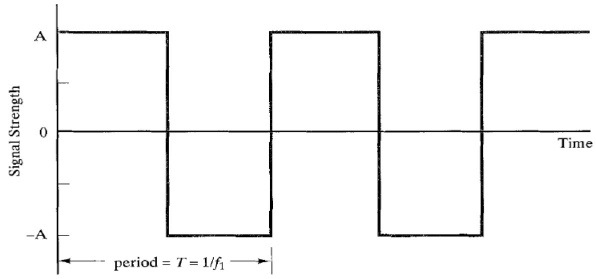


Signal Representation in the Time Domain *(cont.)*

Sine Wave



Square Wave

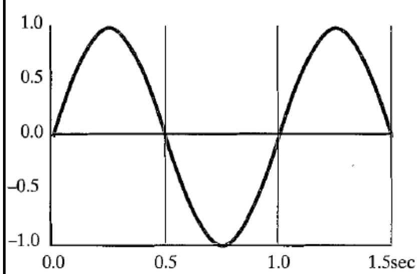


Signal Representation in the Time Domain *(cont.)*

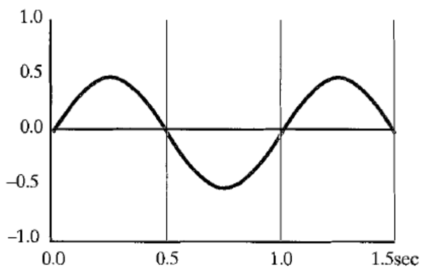
Sine Wave

$$s(t) = A\sin(2\pi ft + \phi)$$

Amplitude, Frequency, Phase



(a) $A = 1, f = 1, \phi = 0$

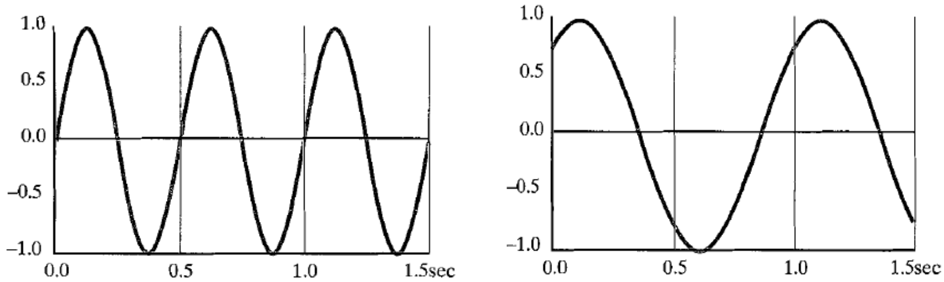


(b) $A = 0.5, f = 1, \phi = 0$

Signal Representation in the Time Domain *(cont.)*

Sine Wave (cont.)

$$s(t) = A \sin(2\pi ft + \phi)$$



(c) $A = 1, f = 2, \phi = 0$ (d) $A = 1, f = 1, \phi = \pi/4$

Signal Representation in the Frequency Domain

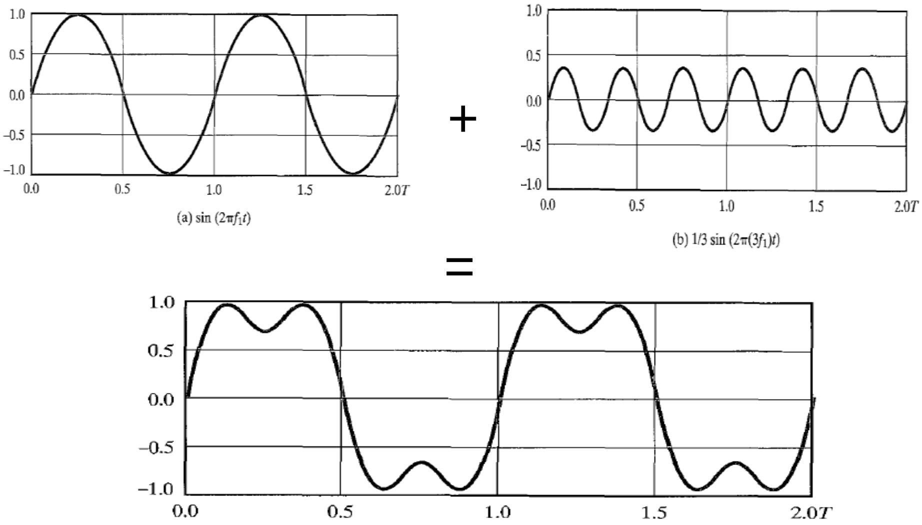
- In practice, an electromagnetic signal will be made up of many frequencies.
- For example, the signal:

$$s(t) = \sin(2\pi f_1 t) + \frac{1}{3}\sin(2\pi(3f_1)t)$$

is made up sine waves of frequencies f_1 and $3f_1$

- The ***spectrum*** *of a signal is the range of frequencies that it contains.*

Signal Representation in the Frequency Domain *(cont.)*

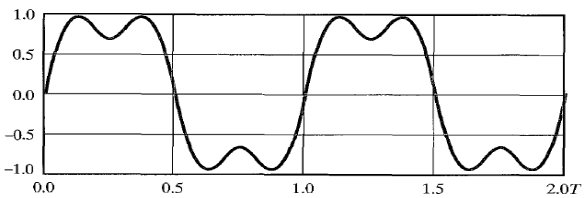


(a) $\sin(2\pi f_1 t)$

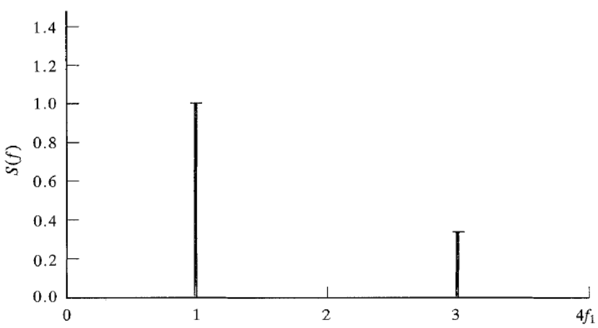
(b) $1/3 \sin(2\pi(3f_1)t)$

(c) $\sin(2\pi f_1 t) + 1/3 \sin(2\pi(3f_1)t)$

Signal Representation in the Frequency Domain *(cont.)*



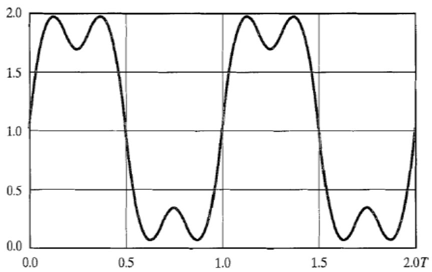
(c) $\sin(2\pi f_1 t) + 1/3 \sin(2\pi(3f_1)t)$



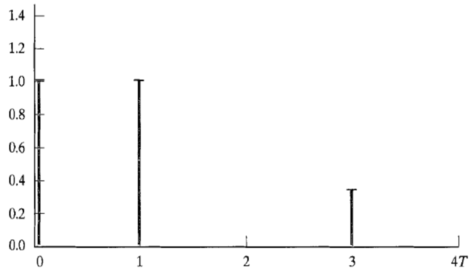
Fourier analysis

Signal Representation in the Frequency Domain *(cont.)*

- If a signal includes a component of zero frequency, that component is a direct current (dc) or constant component.



$s(t) = 1 + \sin + 1/3 \sin(2\pi(3f_1)t)$

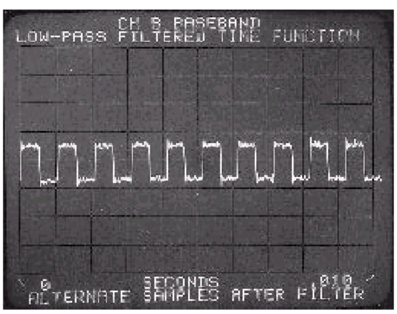


$S(f)$

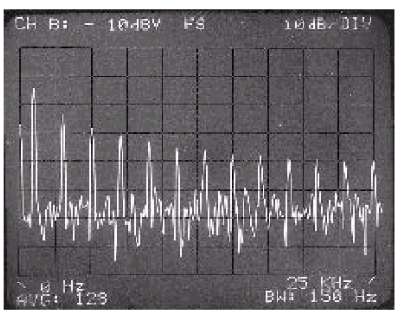
Noise and Interference

- In practical communication systems signals are blurred by noise and interference:

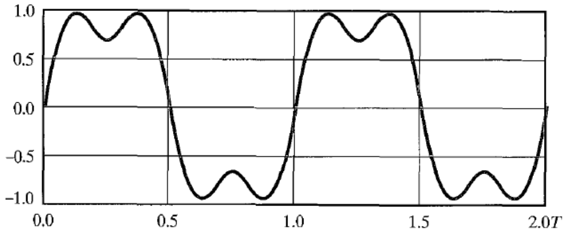
• Time domain



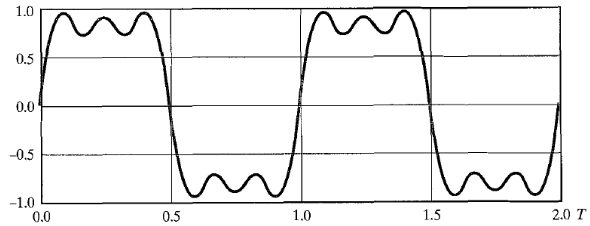
• Frequency domain



Signal Bandwidth

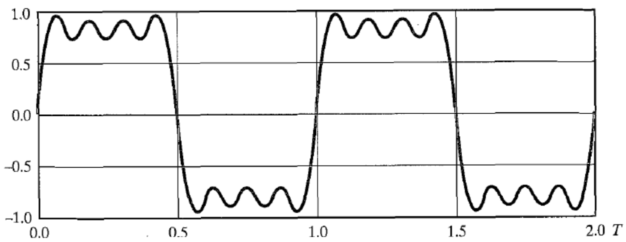


$\sin(2\pi f_1 t) + 1/3 \sin(2\pi(3f_1)t)$

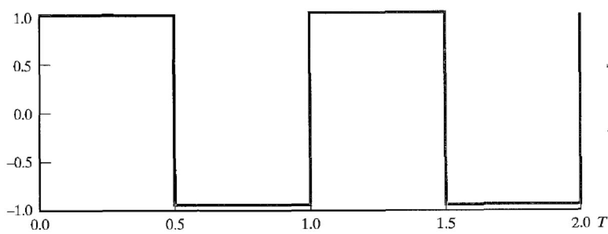


$\sin(2\pi f_1 t) + 1/3 \sin(2\pi(3f_1)t) + 1/5 \sin(2\pi(5f_1)t)$

Signal Bandwidth *(cont.)*



$\sin(2\pi f_1 t) + 1/3 \sin(2\pi(3f_1)t) + 1/5 \sin(2\pi(5f_1)t) + 1/7 \sin(2\pi(7f_1)t)$



$$s(t) = A \times \sum_{k \text{ odd}, k=1}^{\infty} \frac{1}{k} \sin(2\pi k f_1 t)$$

What is the problem?