University of Anbar
College of Engineering
Department of Electrical Engineering

LECTURE NOTES IN:

Fundamentals of Analog Communications And Noise

for the classes: EE3328

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الثقافة هي ما يتبقى بعد ان تنسى كل ما تعلمته في المدرسة
"Education is what remains after one has forgotten what one has learned in school." Albert Einstein

REFERENCES

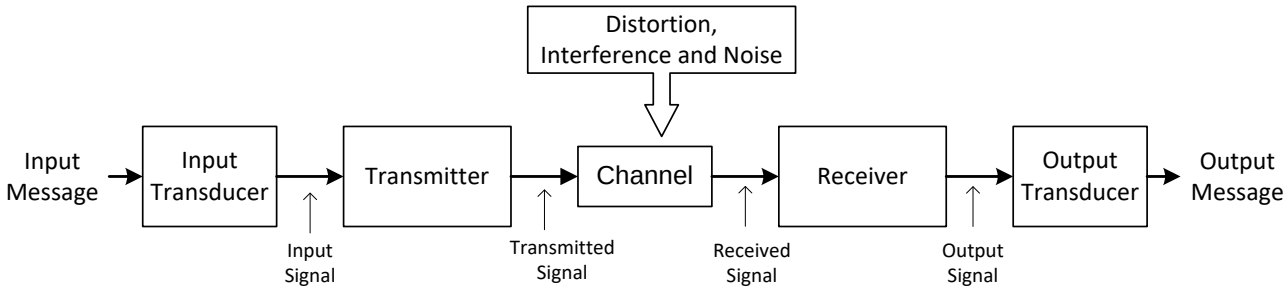
- *Introduction to Communication Systems*. Ferrel G. Stremler.
- Instructor's Lectures.

BIBLIOGRAPHY:

(1) *Modern Digital and Analog Communication Systems*. B. P. Lathi.
(2) *Communication Systems, an Introduction to Signals and Noise in Electrical Communications*. Bruce Carlson.
(3) *Communication Systems Engineering*. John G. Proakis and Masoud Salehi.
(4) *Digital and Analog Communication Systems*. Leon W. Couch.

Part 1 INTRODUCTION TO COMMUNICATION SYSTEMS

A typical Communication system can be modeled as:



The *source* originates the message. If this message is non-electrical (such as human voice or a television picture), it must be converted by an *input transducer* into electrical waveforms referred as the baseband signal.

For efficient transmission, the *transmitter* processes and amplifies the input signal to produce a transmitted signal suited to the characteristics of the transmission channel. Signal processing involves: Modulation and Coding.

The *channel* is the medium that bridges the distance from source to destination, such as: wire, coaxial cable, optical fiber, radio link… etc.

Generally, the signal passes a channel suffers from the following main problems:

(1) Attenuation: the signal power gradually decreases along the distance.
(2) Distortion: the channel changes the shape of the signal.
(3) Noise: the signal is corrupted by random and unpredictable electrical signals. These unwanted signals are produced by natural processes in both internal and external to the system.
(4) Interference: is the contamination by extraneous signals, such as: other transmitters, power lines and machinery, switching circuits… etc.

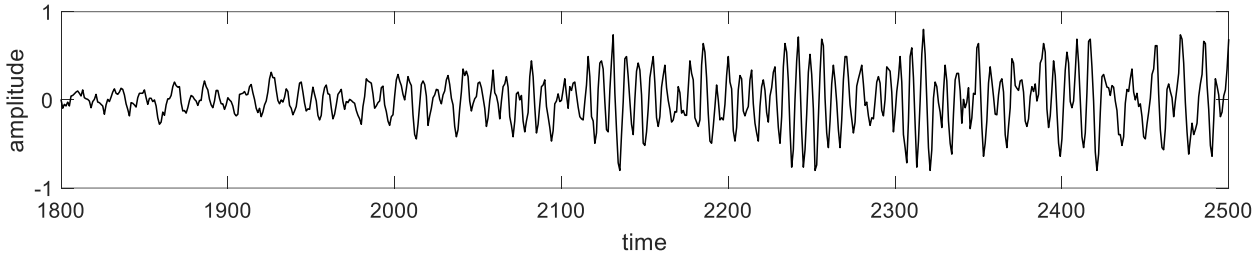
The *receiver* compensates the received signal for the channel effects and reprocesses the received signal by undoing the signal modification made at the transmitter through the demodulation and the decoding. The receiver output is fed to the *output transducer* to convert the electrical signals to its original form: the message.

The main objective of a "brilliant" communication engineer is to design and implement a maximum efficiency system which can send and receiving data with minimum required

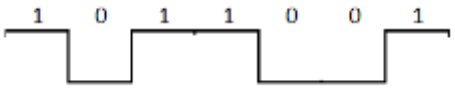
resources (power, frequency band, time, and cost) beside many other issues that must be considered (such as data security, reliability, immunity to noise, better control, weight, size, etc.).

1.1 BASIC DEFINITIONS:

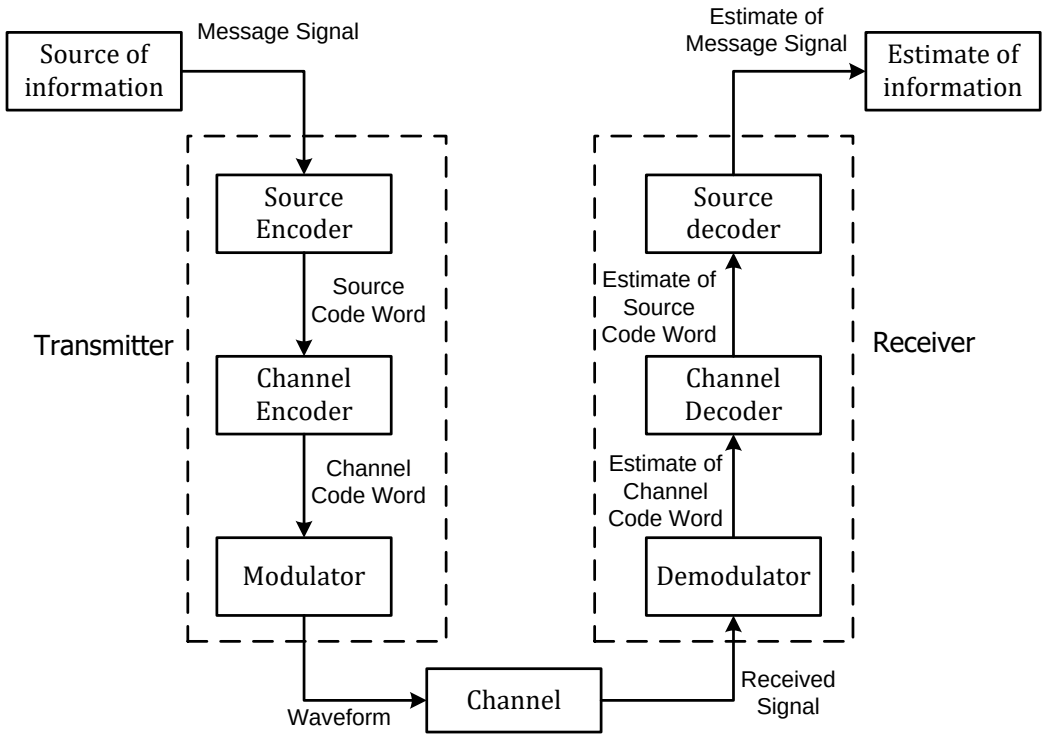
An *Analogue* signal is defined as a physical time varying quantity and is usually smooth and continuous, e.g. acoustic pressure variation when speaking. The performance of an analogue communications system is often specified in terms of its fidelity or quality.



A *digital* signal on the other hand is made up of discrete symbols selected from a finite set, e.g. letters from the alphabet or binary data. The performance of a digital system is specified in terms of accuracy of transmission e.g. Bit Error Rate (BER) and Symbol Error Rate (SER).



The main elements of a digital system are shown in below diagram:



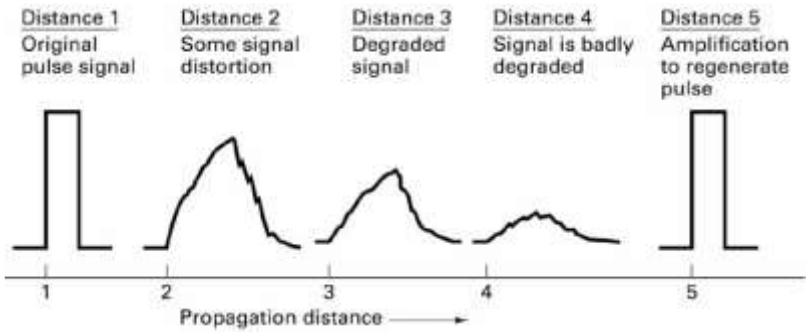
The *source encoder* removes redundant information from the message signal to facilitate the transmission. The opposite is true for the *channel encoder*. It adds redundant bits to the transmission to provide the capability of the error correction and control at the receiver. Finally, the modulator represents each symbol of the channel code word by an analog symbol. The sequence of analog symbols is called a waveform, which is suitable for transmission over the physical channel.

At the receiver, the channel output (the received signal) is processed in the order reverse to that of the transmitter, thereby reconstructing a recognizable version of the original message signal to be finally delivered to the user.

From this description, it is apparent that the design of a digital communication system is rather complex, but nowadays electronics are inexpensive, due to the ever-increasing availability of VLSI circuits in the form of silicon chips. Besides being easy to build, digital communications offer greater tolerance of physical effects (e.g. temperature variations, aging, mechanical vibrations) than its analog counterparts.

Advantages of digital communication systems:

(1) Relatively inexpensive digital circuits may be used.
(2) Privacy is preserved by using data encryption.
(3) Voice, video, and data sources may be merged and transmitted over a common digital system.
(4) Errors can often be corrected using coding.
(5) It is easy to regenerate the transmitted signal to be able to extend the receiver distance. For example: A regenerative repeater:



Digital communication also has disadvantages:

- Generally, more bandwidth is required than that for analog systems.
- Synchronization is required.

1.2 SYNCHRONOUS/ASYNCHRONOUS COMMUNICATIONS

Synchronous (coherent) transmission: A synchronous system is one in which the transmitter and receiver are operating continuously at the same number of symbols per second in the desired phase relationship.

Asynchronous (non-coherent) transmission: in an asynchronous system, no rigid timing constraint is applied between the transmitter and the receiver.

Advantages of synchronous data communications

- Superior noise immunity due to matched filtering; that is. the symbol or bit is averaged over its entire duration giving optimum noise and interference rejection and maximizing signal power.
- Can accommodate higher data rates than asynchronous systems.

Disadvantages of synchronous data communications

- Requires finite time for synchronization to occur.
- Is more expensive and complex than asynchronous operation.