Chapter 1: Introduction

AAiT
Addis Ababa Institute of Technology
አዲስ አበባ ቴክኖሎጂ ኢንስቲትዩት
Addis Ababa University
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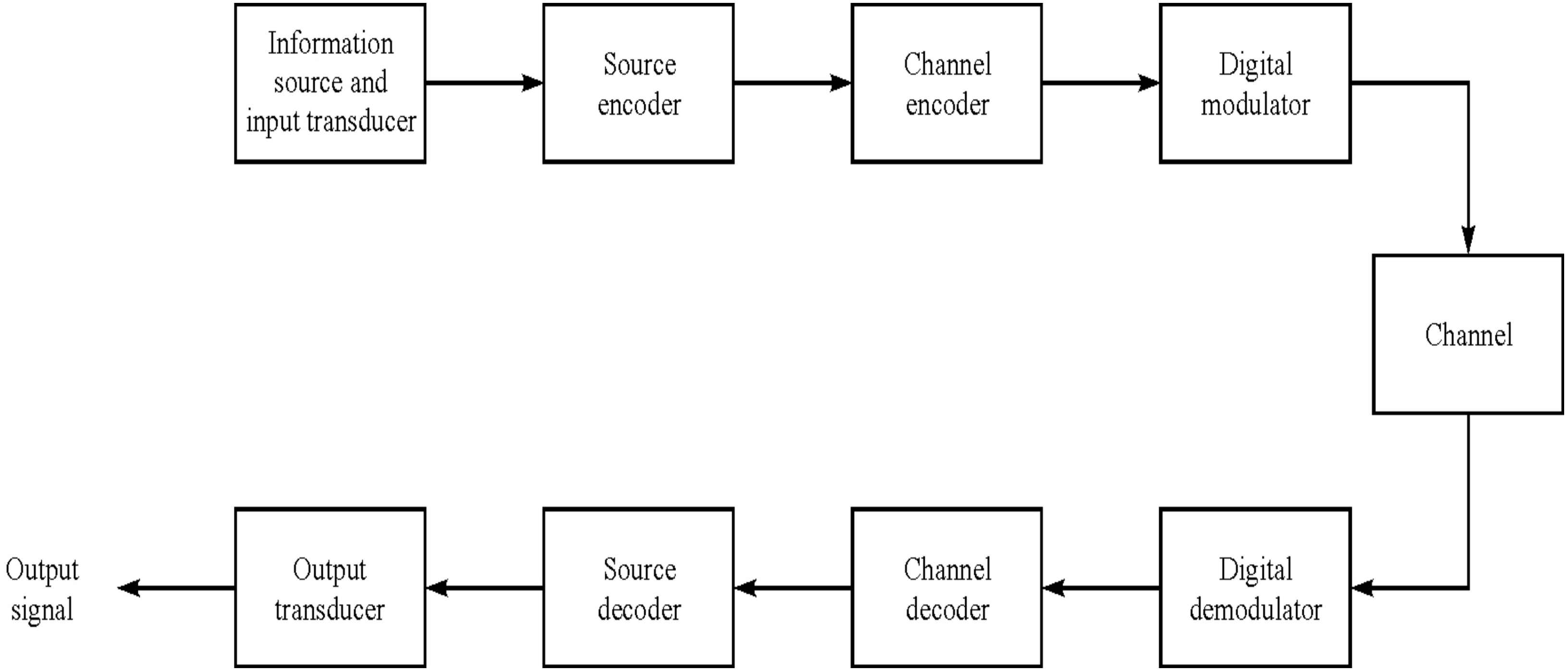
Graduate Program
School of Electrical and Computer Engineering

Course Objectives

1. Present the ***mathematical basis*** and theory of signals and systems that help describe and understand ***digital communication*** techniques and equipment
2. Apply such concepts and ideas to information transmission links which must be made robust in the presence of **noise** and other impairments and perform at rates that are as high as possible
3. Show how such transmission links are used in fixed and mobile data communication systems for voice and video transmissions

Introduction - Basic Elements of Digital Comm. System



Introduction …

- The figure illustrates a functional block diagram of a typical digital communication system showing the key components of the system
  - We will briefly review and discuss the functions of these key elements of the communication system
- Source output
  - The output from an information source could be
    - Analog signal such as voice or video signal or
    - Digital signal that is discrete in time and having a finite number of characters
  - Messages from the source are converted into a sequence of binary digits
  - Ideally, the source message should be represented by as few as possible binary digits

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- Source encoding
  - The process of efficiently converting source outputs into a sequence of binary digits, called *information sequence*
  - The representation of the source output in binary form should have as little or no redundancy (data compression)
- Channel encoding
  - Introduce, in a controlled manner, some redundancy in the binary information sequence
  - The redundancy can be used at the receiver to overcome the effects of noise and other interferences on the transmission channel
  - *Trivial example*: Repeat each binary digit n times

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- *Non-trivial example*: Taking *k* information bits at a time and mapping each *k*-bit sequence into a unique *n*-bit sequence, called the codeword
- ($n > k$) measure of redundancy is the ratio *k/n (or n/k),* called the code rate

- Digital Modulator
  - This is an interface between the channel encoder and the communication channel
  - It maps the coded information sequence into signal waveforms that can be transmitted over the channel
  - Consider the coded sequence is to be transmitted one bit at a time at some uniform rate R bits/s
  - The modulator may simply map the binary digits as follows

$$0 \leftrightarrow s_0(t) = +\cos 2\pi ft \qquad 1 \leftrightarrow s_1(t) = -\cos 2\pi ft$$

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- This is an example of binary modulation in which each bit from the encoder is transmitted separately
  - Called binary phase-shift keying – BPSK

- Alternatively, modulator may transmit b coded information bits at a time using distinct waveforms $s_i(t)$, i= 0,1,…M-1, $M = 2^b$ called M-ary modulation

- Note here that a new b-bit coded sequence enters the modulator every b/R seconds
- If the channel bit rate is fixed at R, the amount of time available to transmit one of the M waveforms (corresponding to the b-bit sequence) is b times the time period in a system that uses binary modulation

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- Communication Channel: Physical medium that is used to send the signal from the transmitter to the receiver
- Examples include
  - Wireless transmission- the atmosphere or free space
  - Wireline, optical fiber, coaxial cables
  - Storage channels: Information storage and retrieval devices- magnetic tapes, compact discs, etc
- Transmitted signals are corrupted, in a random manner, by a variety of additive noise such as thermal noise, atmospheric noise, man made noise, etc and also attenuated in amplitude

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- Channels can be modeled in a variety of ways that take into account the particular properties of the channel
  - Examples are additive noise channel, linear filter channel, etc
- Digital demodulator: The demodulator processes the channel-corrupted transmitted waveforms and reduces them to a sequence of numbers (digits) that represent estimates of the transmitted coded data symbols (binary or M-ary)
- The channel decoder attempts to reconstruct the original information sequence from the knowledge of the code used and the redundancy contained in the received data estimate.

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- A measure of how accurately the demodulator and decoder recover the original sequence is the average probability of bit-error at the output of the decoder for a given power level (signal-to-noise-ratio)
- The probability of error is in general a function of
  - Code characteristics
  - Type of waveforms used
  - Transmitter power
  - Channel characteristics and
  - Method of demodulation and decoding
- We will explore most of these factors that affect the reliability of digital communication

Major Factors for the Growth of Digital Communication

1. Impact of the Computer: Computers are processors and sources of data as well as tools for communication
2. Digital communication offers flexibility and compatibility: The adoption of a common digital format makes it possible for a transmission system to handle many different sources of information in a flexible manner
3. Improved reliability due to improved theory, microelectronics and system design
4. Availability of wide-band channels such as optical fibers, coaxial cables and geo-stationary satellites
5. Availability of integrated solid-state electronics technology makes possible increased system complexity by orders of magnitude in a cost effective manner