Modern Communication Systems
ENEE 3306
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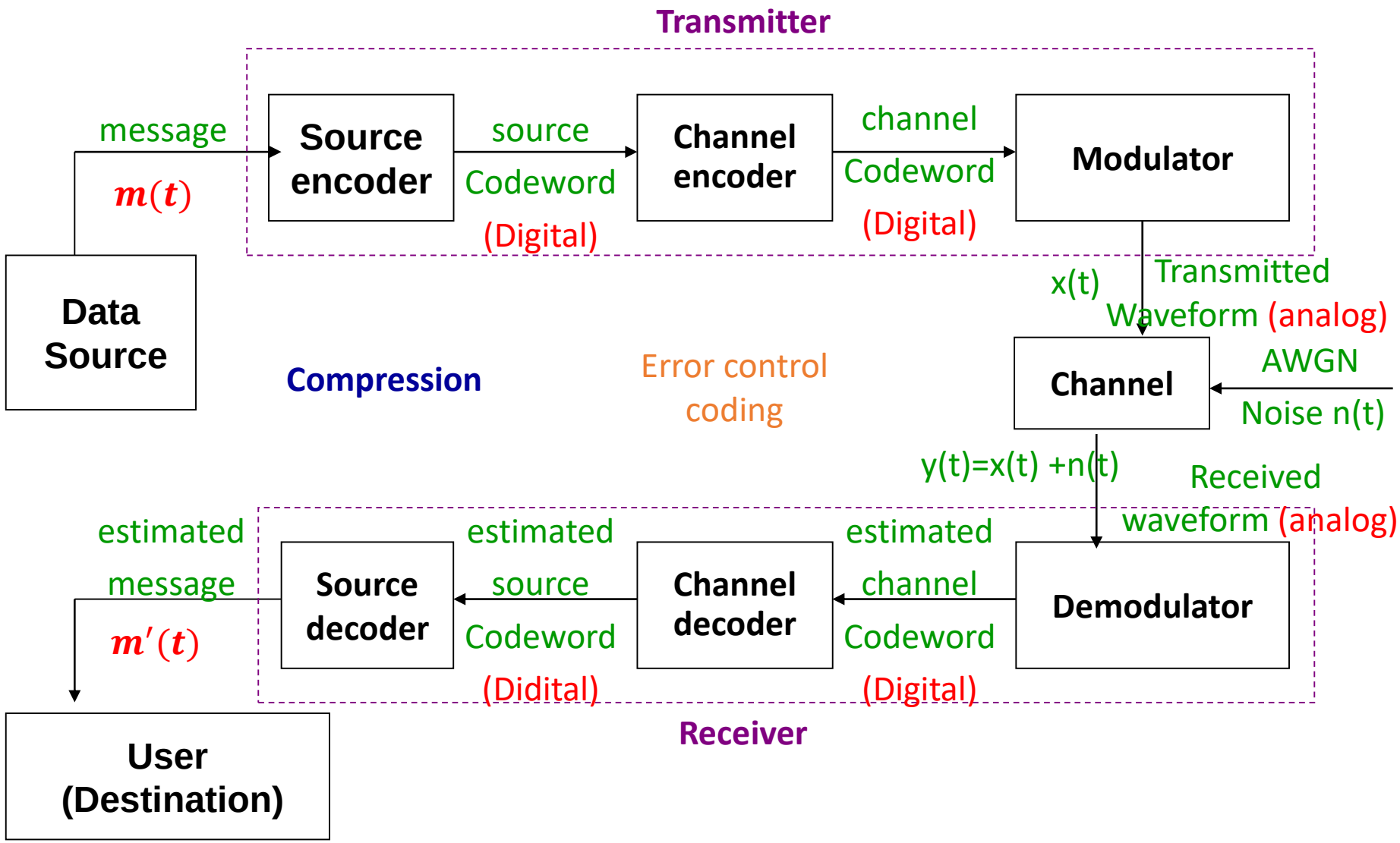
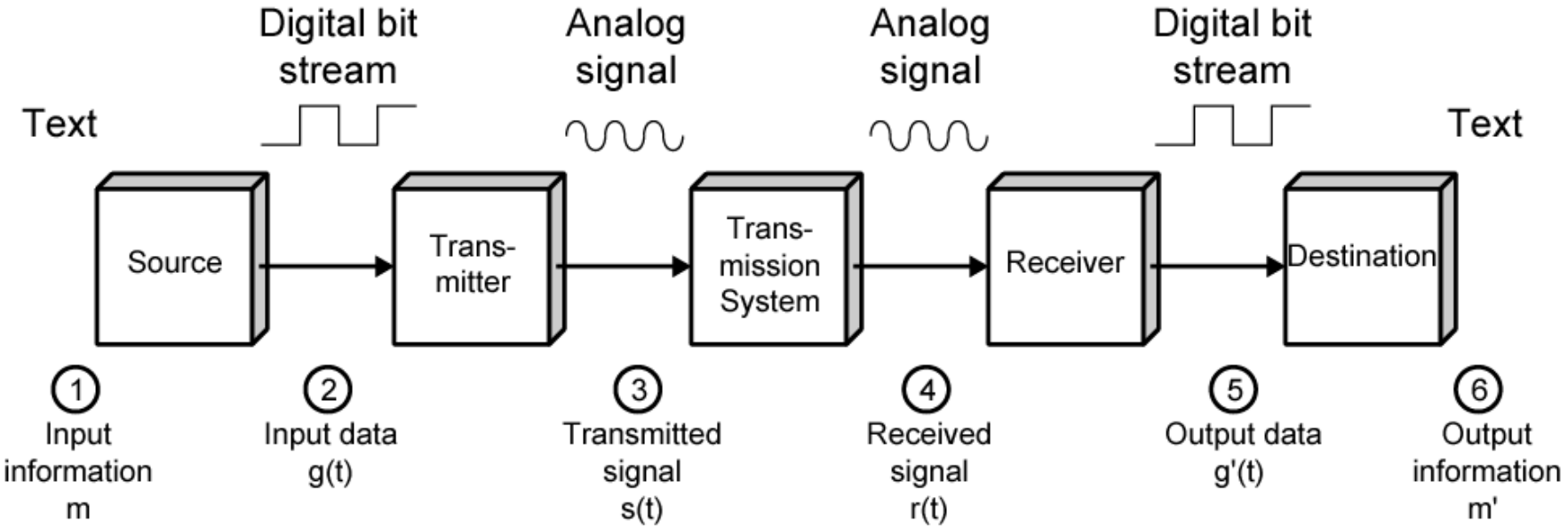
Modern Communication Systems ENEE 3306
Unit 0: Introduction to Digital Communication Systems

- Block Diagram of a Digital Communication System
- The Source Encoder
- The Channel Encoder
- Distortion-less Transmission
- Transmission Impairments over the Channel
- Digital Modulation Schemes
- Analog vs Digital: Advantages and Disadvantages

A Digital Communication System



A Digital Communication System



A distortion-less communication system is one for which m' is an exact replica of m. The task of the system is to minimize the difference between m and m' in the presence of noise, i.e., to minimize the distortion : $E(m - m')^2$; **MSE**

Model of a Communication System

- The purpose of a communication system is to transmit information from a source located at one end to a user (destination) located at another end.
- the source could be an analog signal (e.g., voice), which can be converted into a digital signal via:

➢**sampling and quantization** (output belongs to a finite set of countable symbols, $M = \{m_1, m_2, \ldots, m_n\}$).

➢**sampling, quantization, and encoding**. Output is binary, M={0,1}

- the source could also be digital in nature (e.g., email text), Binary or M-ary.
- The **modulator converts the bits of the channel codeword into waveforms suitable for transmission over** the channel. They may be modulated in amplitude, phase, or frequency (e.g., ASK, PSK, FSK, QPSK).

Model of a Communication System

- The *channel* is the medium over which the signal is transmitted, (wired or wireless), like free space, an optical fiber, transmission lines, twisted pair of wires….

  Here signal is distorted due to:

- Linear distortion: Amplitude distortion and/or phase distortion. Channel does not obey the distortion-less condition for transmission:

$$y(t) = kx(t - t_d)\text{ , time-domain}$$

$$Y(f) = kX(f)e^{-j2\pi f t_d}\text{ , frequency-domain}$$

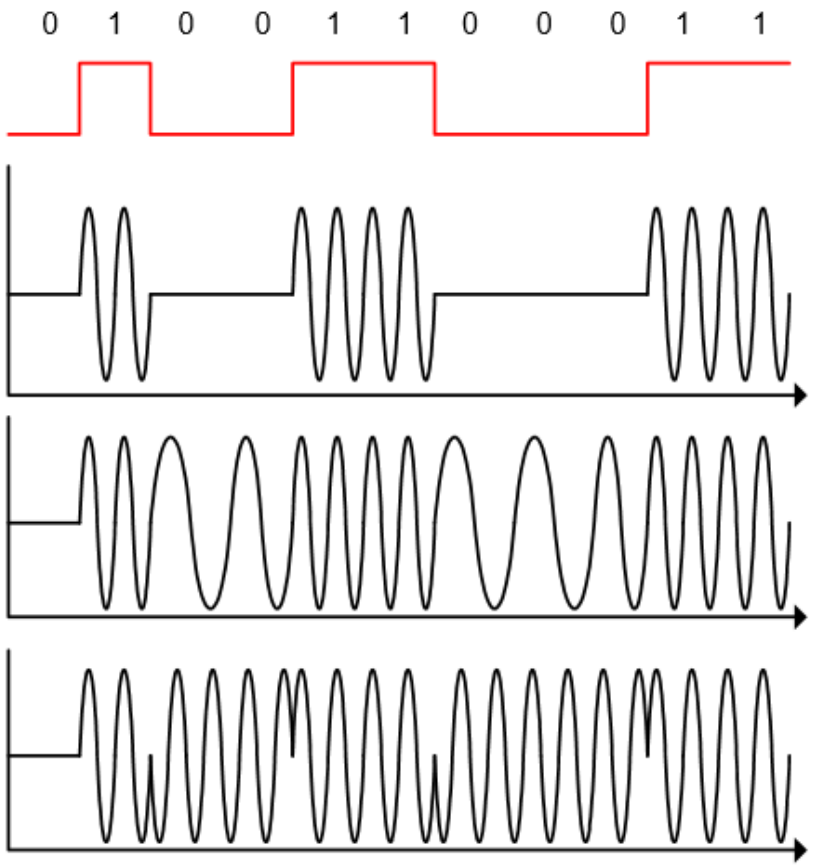
k: constant amplification

t_d: constant time delay

Model of a Communication System

- Nonlinearities and/or imperfections in the frequency response of the channel (channel generates new frequencies not originally present in the signal).
- Input: $x(t) = \cos(2\pi f_0 t)$;
- Output: $y(t) = 0.9cos(2\pi f_0 t) + 0.1\cos(6\pi f_0 t)$
- Noise and interference are added to the signal during the course of transmission (multiple copies at destination arriving at different times from radio waves bouncing on buildings, etc);
- Input: $x(t) = \cos(2\pi f_0 t)$;
- Output: $y(t) = 0.8cos(2\pi f_0(t - t_0) + 0.4cos(2\pi f_0(t - 2t_0)$
- The purpose of the *receiver* is to recreate an estimate of original signal x(t) from the degraded version x(t) + n(t) of the transmitted signal over the noisy channel .
- *Here, demodulation takes place*

Digital Modulation Schemes



Original signal (in a pulse sequence)

Amplitude shift-keying (ASK)

Frequency shift-keying (FSK)

Phase shift-keying (PSK)

Analog vs Digital: Advantages and Disadvantages

An analog signal can take an infinite variety of shapes. The distortion caused by noise cannot be removed by amplification or filtering.

Advantages of Digital Transmission

- Digital signals are more immune to channel noise by using channel coding techniques where error correction can be implemented (ideally, perfect decoding is possible by virtue of Shannon channel coding theorem).
- Digital signals belong to a finite set of possible waveforms. Repeaters along the transmission path can identify the transmitted digital waveform logically (0 or 1) and regenerates a noise free pulse sequence.
- Digital signals derived from all types of analog sources can be represented using a uniform format.
- Digital signals are easier to process by using microprocessors and VLSI
- Digital systems are more flexible to implement and allow for implementation of sophisticated functions and control.

Analog vs Digital: Advantages and Disadvantages

- Digital signals make use of digital signal processing techniques (encryption, error control coding,…). This will enhance security of the transmitted signal.
- Digital circuits are less subject to distortion and interference
- Digital circuits are more reliable and less expensive than analog circuits

Few Disadvantages of Digital Transmission

- Heavy signal processing
- Synchronization is crucial
- Transmission bandwidth is large
- When the S/N ratio drops below a certain value, the quality of service can change suddenly from very good to very bad