Recap of Class 1:

- Three fundamental parts of a communication system:
  1. Transmitter (Tx)
  2. Receiver (Rx)
  3. Electromagnetic waves propagating between Tx and Rx

- The Tx transforms an input (message/signal) to a state where it can be physically sent from A → B

- The Rx does the opposite, acquiring the transmission and converting it back to a useful form (message/signal)

- The Electromagnetic waves are the channel:
  - (A) Free Space (wireless)
  - (B) Optical Fiber
  - (C) Metallic wire (Copper, aluminum, etc...)
  - (D) Coaxial Cable
    - BNC etc...
    - SMA

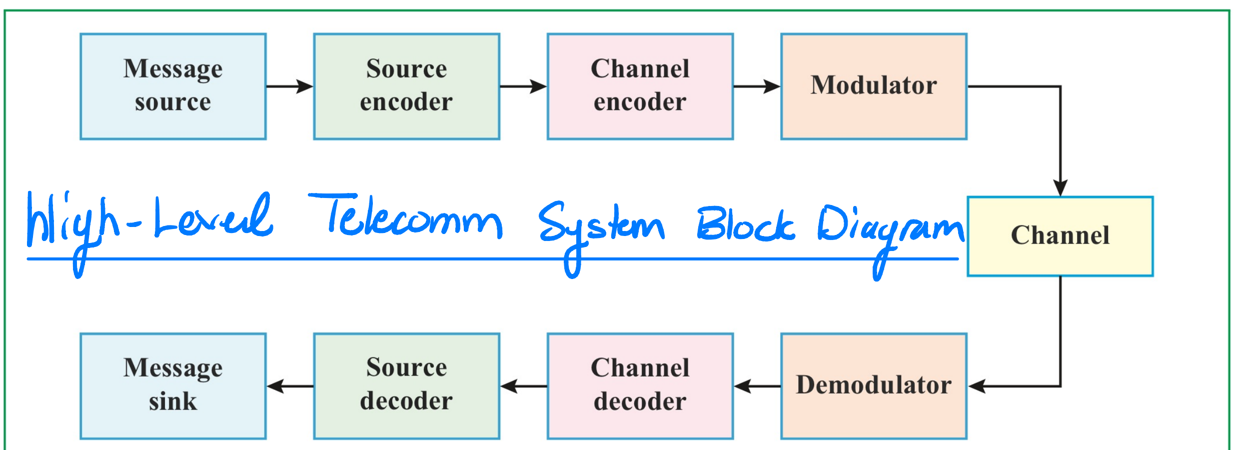


Figure 1-1: A high-level block diagram of a communication system with the different high-level functional elements represented by blocks.

High-Level Telecomm System Block Diagram

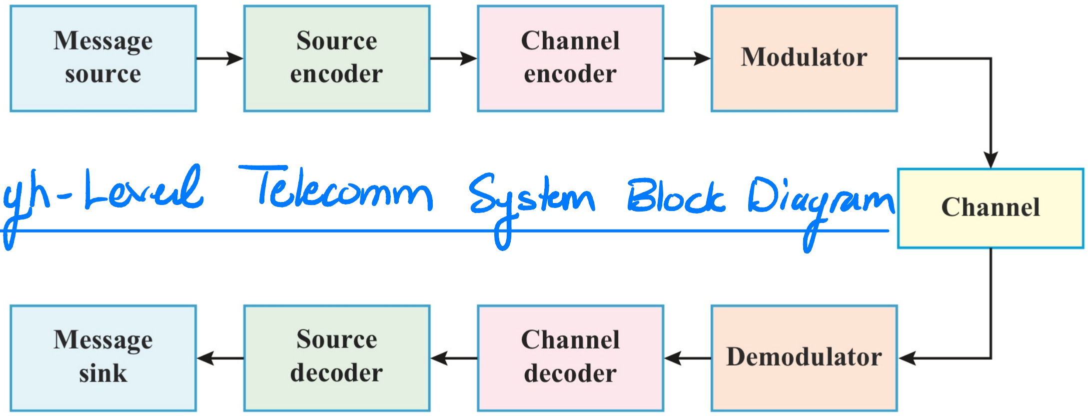


Figure 1-1: A high-level block diagram of a communication system with the different high-level functional elements represented by blocks.

- The Message Source is a system whose output is an input to the Telecom system
  - i.e. what are you trying to send to your friend?
  - Audio, video, image, etc...
- The Source Encoder represents the message source
  - i.e. the message source is represented as an analog or digital signal
  - In the modern age, the information is converted into digital signal, even if the message is analog → voice and video are converted to digital
  - Think of the Source Encoder as the initial "packing up" of the signal
- The Channel Encoder helps fix errors introduced by the channel. (Redundancy added to prep for errors).
- The Modulator converts info (bits) into a sequence of electrical (Voltage or Current) signals to be sent "through the channel"

High-Level Telecomm System Block Diagram

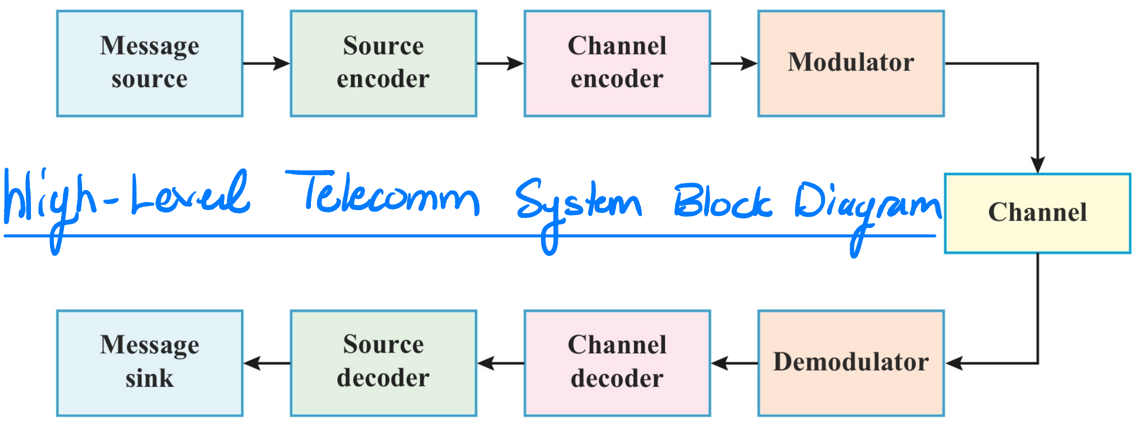


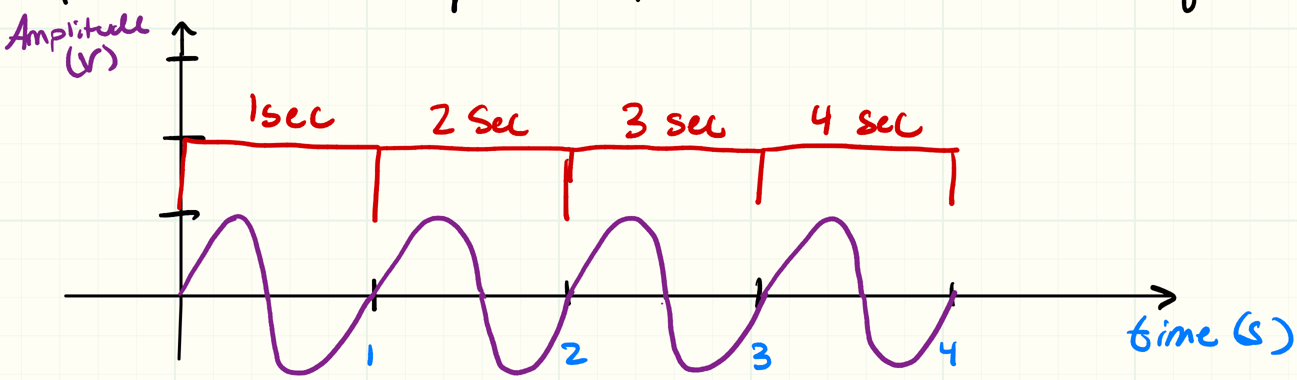
Figure 1-1: A high-level block diagram of a communication system with the different high-level functional elements represented by blocks.

- The channel conveys the energy from Tx to Rx, but may introduce attenuation, distortion, noise, and interference
  - We like to think of the channel as the combo of the EM wave and the medium
  - Medium → Vacuum, free space, air, water, BNC, SMA,
- The Demodulator is responsible for taking the electrical (Voltage or Current) signals that went through the channel and transform them back to an info signal (message), but with some natural amount of delay, noise, attenuation, or interference
- The Channel Decoder will then try to fix the errors from the channel and back-engineer added redundancy
- The Source Decoder simply performs the reverse operation of the Source Encoder to recover the message
  - Imagine Transforms (Inverse) → $1 = \frac{5}{5} \rightarrow \frac{5}{5} = 1$
- The Message Sink is the "final destination"
  - Speaker, TV, PC, IPhone, etc...

Signals and Systems

The following are common terms used for Messages (Info)

- Frequency is measured in Hz or cycles/sec and represent how many times per second a waveform cycles



60 Hz → 60 cycles per second → Power freq. of North America

- If we wanted to know how long one cycle takes:

$$f = \frac{1}{T} \rightarrow 60 = \frac{1}{T} \rightarrow T = \frac{1}{60} \rightarrow \boxed{T = 16.67ms}$$

- If we wanted to know how long one cycle of 2.45 GHz was:

$$f = \frac{1}{T} \rightarrow 2.45 \times 10^9 = \frac{1}{T} \rightarrow T = \frac{1}{2.45 \times 10^9} \rightarrow \boxed{T = 0.41 ns}$$

- Speech / Audio signals normally detectable by humans are in the range of 80 Hz → 20 kHz

- Video signal is a sequence of still images displayed back to back → we call each of these a frame
  - These frames are projections of 3D world onto 2D
  - The rate of the displayed frames is called frame rate with units frames per second (FPS)
  - Funfact → 24 FPS is the minimum for humans to "see motion"

Signals and Systems

- An Image Signal is represented digitally by using a rectangular grid and assigning a number to the amplitude
- This rectangle grid has N # of pixels that are represented by the amplitude number
  - The "matrix size" or rectangular grid area of pixels can be thought of as the Resolution (i.e. 1920×1080)
- Pixels have brightness (amplitude) and color where the color is represented by the bits per pixel (BPP)
  - Gray Scale → 8 bits → $2^8 = 256$ tonal levels
  - Color Video → 8 bits per major color - Red, Green, + Blue (RGB)
    - ↳ Also called Absolute Color Space
- We say that Data Rate is : $\frac{b}{sec}$

Pixel width (W) * Pixel Height (H) $\left[\frac{p}{f}\right]$ * Bits / Pixel $\left[\frac{b}{p}\right]$ * Frames/sec $\left[\frac{f}{s}\right]$

Pixels per frame

- We say that Video Size is : Data Rate * Duration [b]

Example ①:

Given a video with total duration of 1 hour (3600 s), frame size of 640×480 $(W \times H)$, frame rate of 25 fps, and 24 bits/pixel, find the bit rate (Mb/s) and video size (GB)

Bit Rate $= W * H * BPP * FPS = 640 * 480 * 24 * 25$

$= 184{,}320{,}000 \ \frac{\text{bits}}{\text{sec}} \rightarrow \boxed{184.32 \text{ Mb/s}}$

Video Size $=$ Data Rate $*$ Duration $= (184.32 \text{ Mb/s}) * (3600 \text{ s})$

$= 663{,}552 \text{ mb} \rightarrow 663.55 \text{ Gb} \rightarrow \boxed{82.94 \text{ GB}}$

Remember → There are 8 bits in 1 byte!

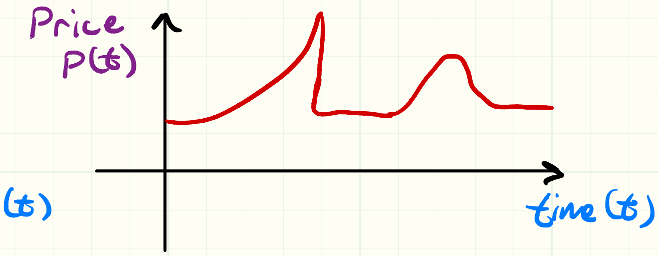
bits ÷ 8 → byte

Signals and Systems

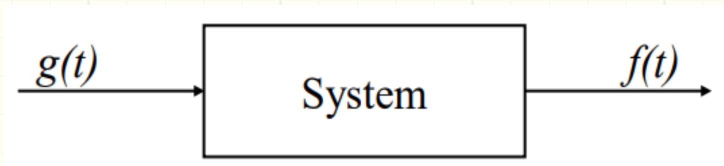
- We know from ECE 3330, that everything in the real world involves signals and systems

Signal: A real/complex valued function of one or more variables

(A) Voltage across a Resistor (B)



System: Takes signals as inputs ; produces signals as outputs



- As we mentioned in class 1, there are many signal classes:

Table 2-2: Classification of signals.

periodic	vs.	nonperiodic
continuous	vs.	discrete
continuous-time	vs.	discrete-time
real-valued	vs.	complex