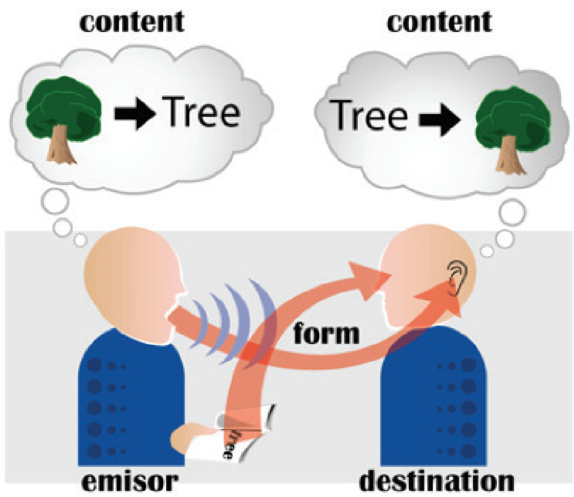
Communications Lab.	Fall 2017
Amplitude Modulation (AM)	
Prof. Hyunggon Park	Lecture Note

1 Key Terms

- communication, analogue, discrete, digital
- noise, amplitude, modulation, demodulation

2 Communications

- Definition: communication is a process of transferring information from one entity to another



3 Types of Signals

- Definitions:
  - An analog signal is a datum that changes over time – continuous
  - A discrete-time signal is a sampled version of an analog signal: value of the datum is noted at fixed intervals rather than continuously.
  - A digital signal is a quantized discrete-time signal

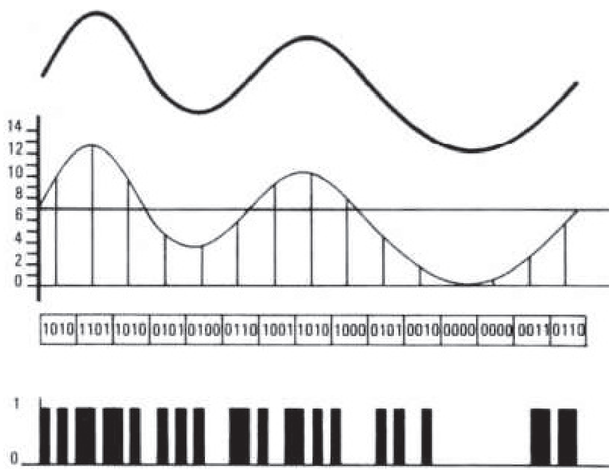
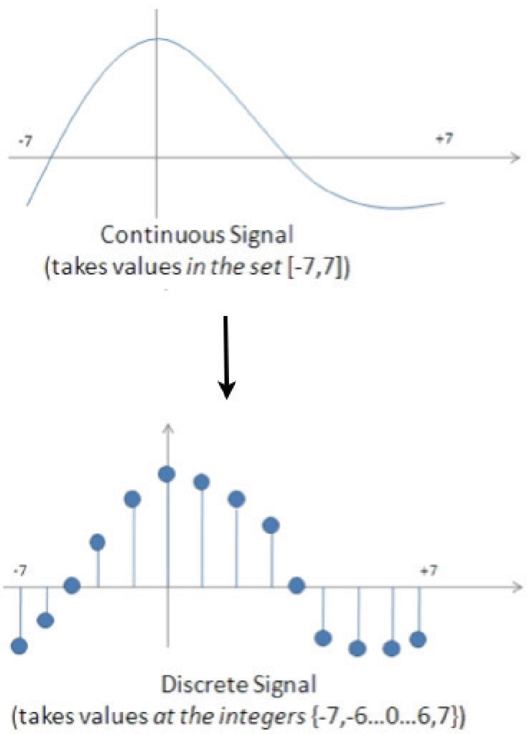
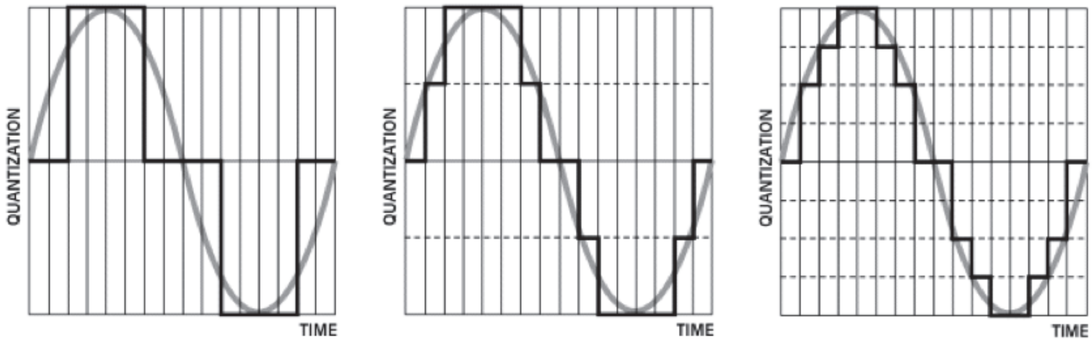


Figure 1: Analog and digital signals. Excepted from Deleuze's Analog and Digital Communication, Isomorphism, and Aesthetic Analogy

- Example



- Example: Quantization



  - All of them are discrete and digital signals
  - Digital signals with different quantization levels

4 Modulation

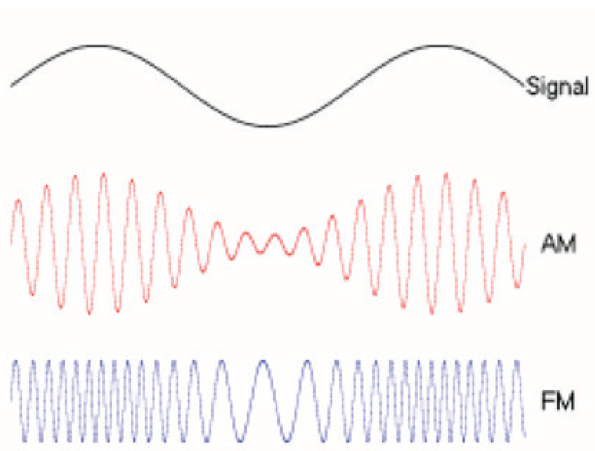
- Definition: Process of conveying a message signal inside another signal that can be physically transmitted.

- Message signals:
  - Digital bit stream
  - Analog audio signal

- Alternatively, modulation of a sine waveform is used to transform a baseband message signal to passband signal

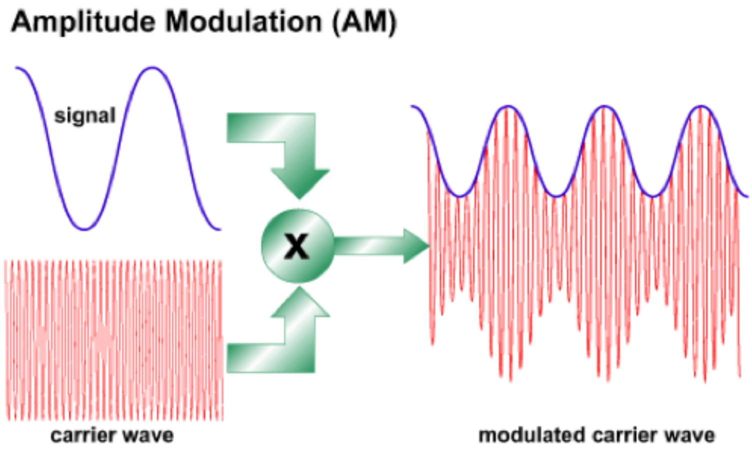
- Analog and Digital Modulations
  - Analog modulation - applied continuously in response to the analog information signal
    - AM (Amplitude Modulation): amplitude of carrier signal is varied in accordance to instantaneous amplitude of modulating signal
    - Angle modulation:
      - Frequency modulation (FM): frequency of carrier signal is varied in accordance to instantaneous value of modulating signal
  - Digital modulation - analog carrier signal is modulated by a digital bit stream.

- Illustration:

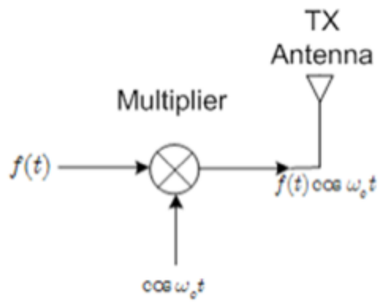


5 AM - Revisit

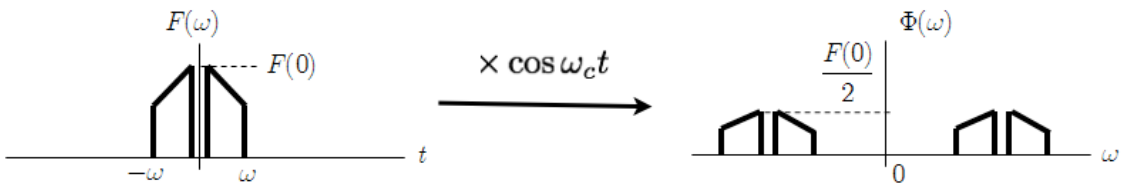
- Property: Amplitude of carrier signal is varied in accordance to instantaneous amplitude of modulating signal.



- More details:
  - General sinusoidal signal: $\phi(t) = f(t)\cos\theta(t)$
  - Moreover, $\theta(t) = \omega_c t + \gamma(t)$. For AM, $\gamma(t) = 0$.
  - Therefore, $\phi(t) = f(t)\cos(\omega_c t)$, which is called *modulated* signal.



- Recall: Fourier Transform Pair
  - Definition:
$$f(t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} F(\omega)e^{j\omega t}d\omega \quad \Leftrightarrow \quad F(\omega) = \frac{1}{2\pi}\int_{-\infty}^{\infty} f(t)e^{-j\omega t}dt$$
  - Modulation Property:
$$f(t)e^{j\omega_c t} \Leftrightarrow F(\omega - \omega_c)$$
  - Euler's relationship:
$$\cos x = (e^{jx} + e^{-jx})/2$$
  - For modulated signal $phi(t) = f(t)\cos(\omega_c t)$,
$$\Phi(\omega) = \frac{1}{2}F(\omega + \omega_c) + \frac{1}{2}F(\omega - \omega_c)$$



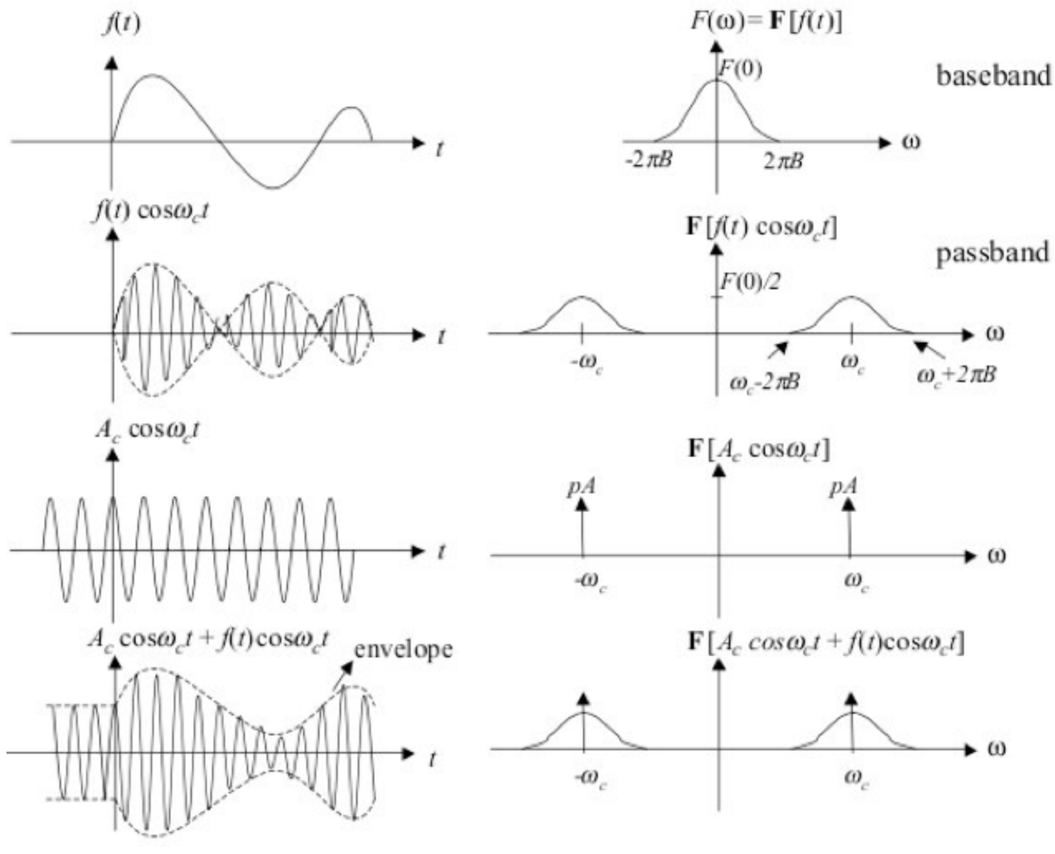
- Double-Sideband Large-Carrier (DSB-LC)
  - Simply adding a carrier term:

$$\phi_{AM} = f(t)\cos(\omega_c t) + A\cos\omega_c t$$

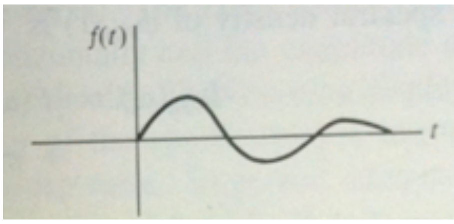
  - Spectral density:

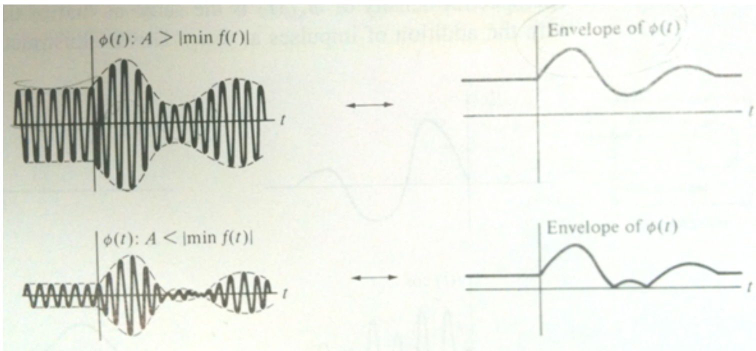
$$\Phi_{AM} = \frac{1}{2}F(\omega+\omega_c) + \frac{1}{2}F(\omega-\omega_c) + \pi A\delta(\omega+\omega_c) + \pi A\delta(\omega-\omega_c)$$

  - Spectral density of DSB-LC



− Modulation Index

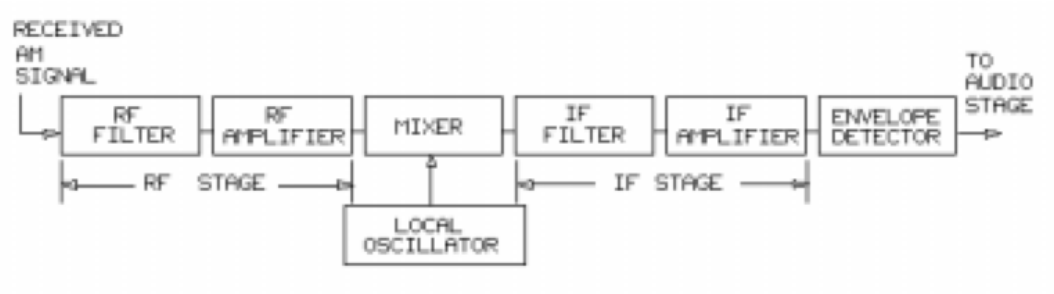




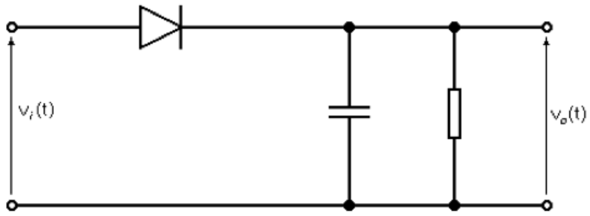
* Define modulation index

$$m = \frac{\text{peak DSB-SC amplitude}}{\text{peak carrier amplitude}} =$$

- Demodulation
  - AM Receiver

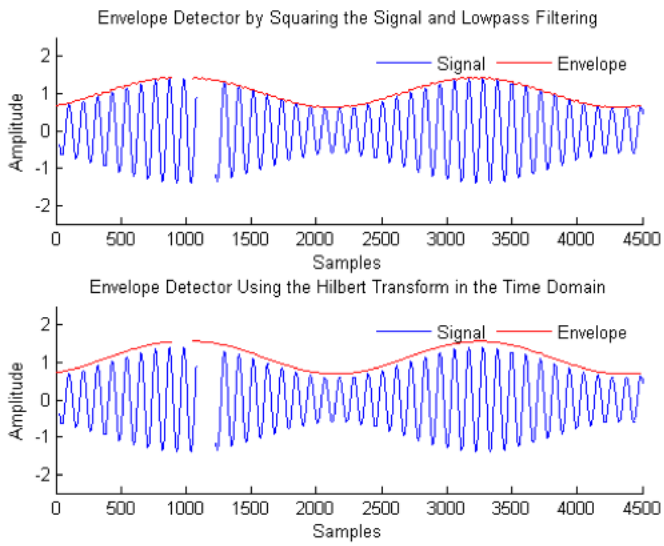


– Envelope Detector



- Circuits:
  - Input: high-frequency signal
  - Output: "envelope" of the original signal.
- Capacitor
  - stores up charge on the rising edge
  - releases it slowly through the resistor when the signal falls.

– MATLAB Example:

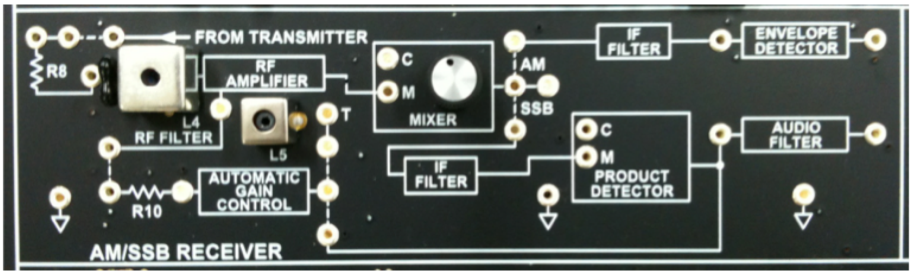


6 Lab Experiment

- AM Transmitter (TX)

  - You may play by changing carrier frequency, modulation index, AM/SSB modes, etc.

- AM Receiver (RX)



  - Inductors are very FRAGILE: Please be VERY careful to handle them
  - Sometimes, IF filter and envelope detector do not work well. In this case, try to see the very front input signal to these blocks these are enough for your report (i.e, bypassing blocks that are not working)