



BENHA UNIVERSITY  
FACULTY OF ENGINEERING AT SHOUBRA

**ECE-291**  
**Electronic Engineering**

Lecture #4  
Modulation Circuits

**Instructor:**  
**Dr. Ahmad El-Banna**



# Agenda

- What's Modulation?
- Applications
- Basic Modulation Types
- Examples of Modulation Circuits

# BASICS OF MODULATION



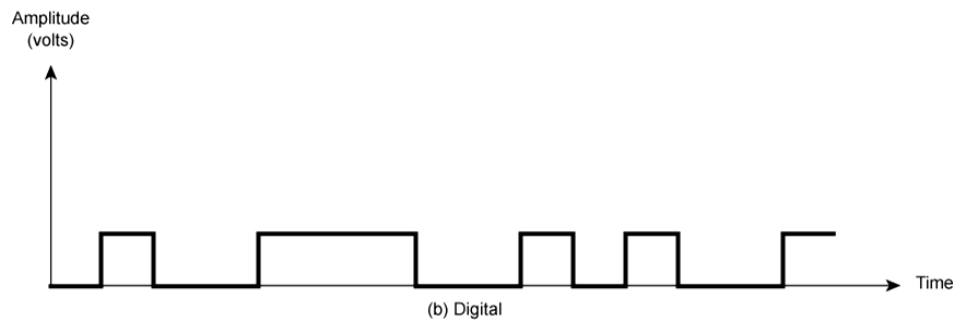
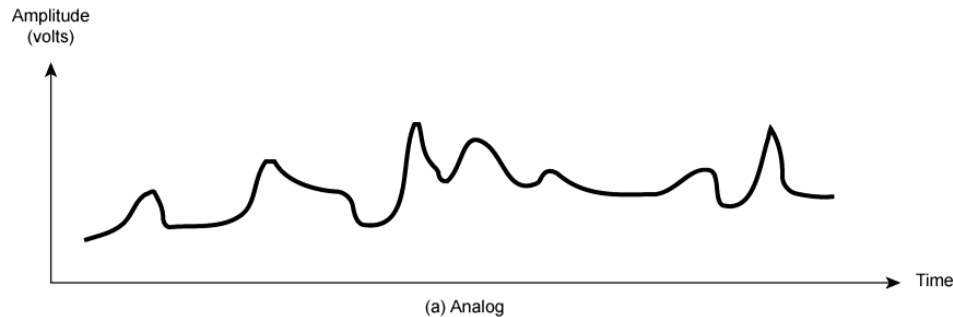
# What's Modulation?

- **Modulation** is the process of varying one or more properties of a periodic waveform, called the *carrier* signal, with a modulating signal that typically contains information to be transmitted.
- A **modulator** is a device that performs modulation.
- A **demodulator** (sometimes *detector*) is a device that performs demodulation, the inverse of modulation.
- A **modem** (from modulator–demodulator) can perform both operations.
- Main **types** of Modulation:
  - Analog (transfer an analog signal)
    - AM, FM, PM, ...
  - Digital (transfer of a digital bit stream)
    - ASK, FSK, PSK, ...



# Analog vs. Digital

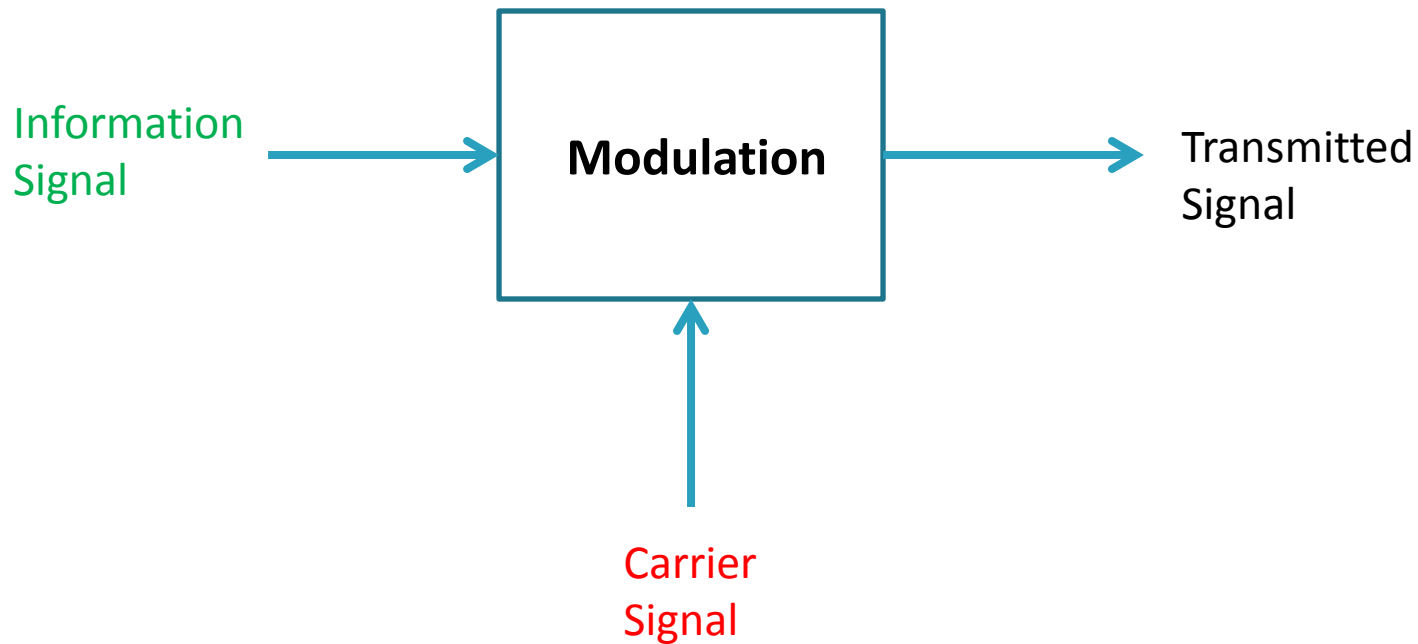
- Analog signal
  - Signal intensity varies in a smooth, **continuous**, fashion over time – no breaks
- Digital signal
  - Signal intensity maintains constant **level** for some period of time and then changes to another constant level – **discrete** signals



# Modulation Applications

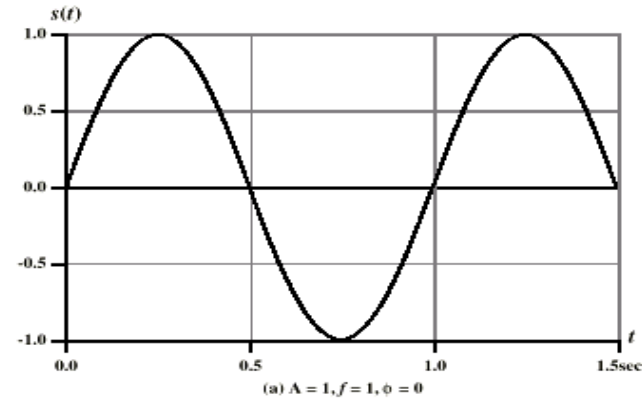
- Radio Transmission
- TV Broadcasting
- Mobile Communications
- Computer Systems
- Telephone Networks
- Satellite systems
- ...
- Generally, any telecommunication system

# Modulation Concept



# Sine Wave as a Carrier Signal (periodic continuous signal)

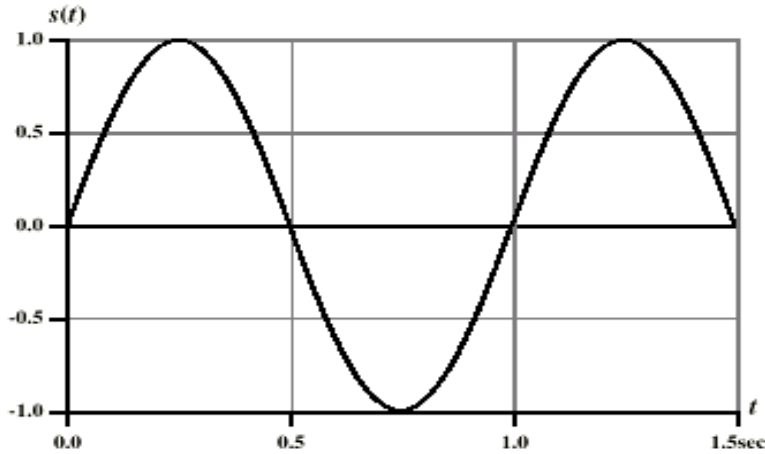
- Peak amplitude (A)
  - **Maximum strength** of signal
  - Typically measured in volts
- Frequency (f)
  - **Rate** at which signal **repeats**
  - Hertz (Hz) or cycles per second
  - Period (T) is time to repeat  $T = 1 / f$
- Phase ( $\phi$ )
  - Relative **position in time** within a single period



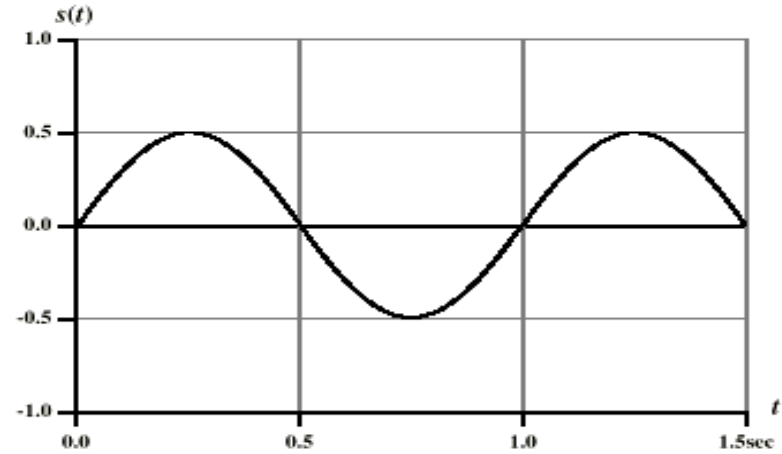


# Varying Sine Waves

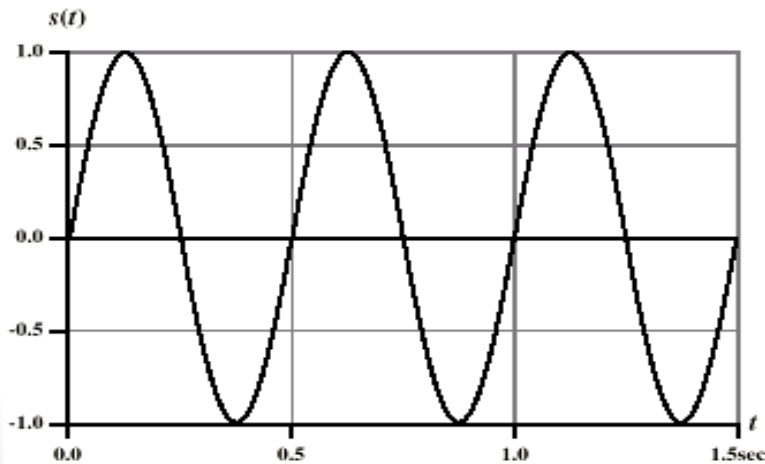
$$s(t) = A \sin(2\pi ft + \Phi)$$



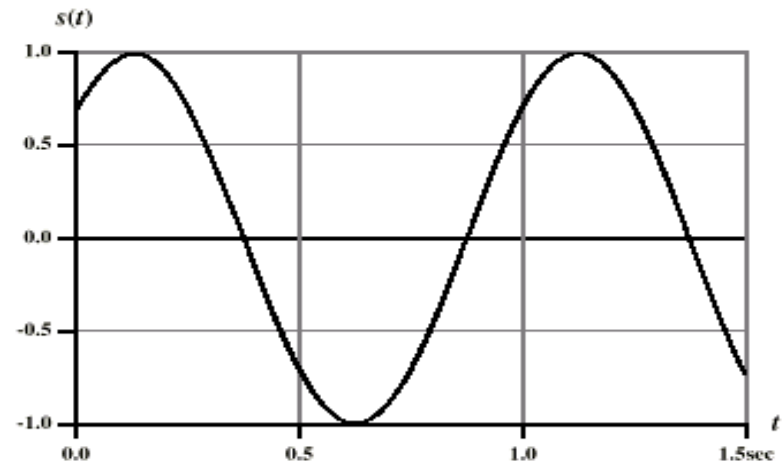
(a)  $A = 1, f = 1, \phi = 0$



(b)  $A = 0.5, f = 1, \phi = 0$



(c)  $A = 1, f = 2, \phi = 0$

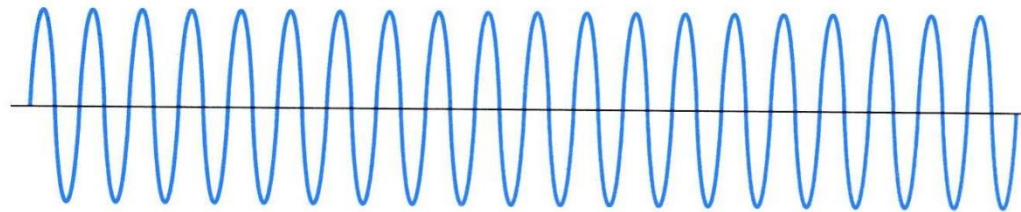


(d)  $A = 1, f = 1, \phi = \pi/4$

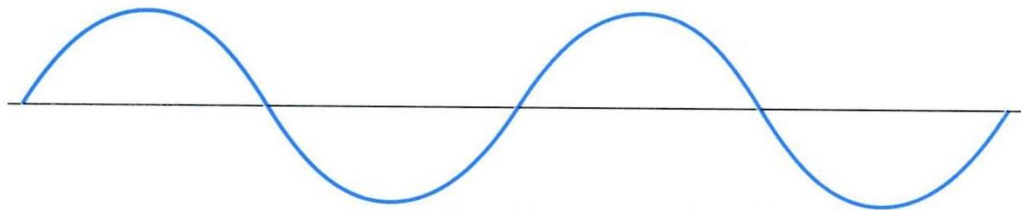


# Analog Modulation

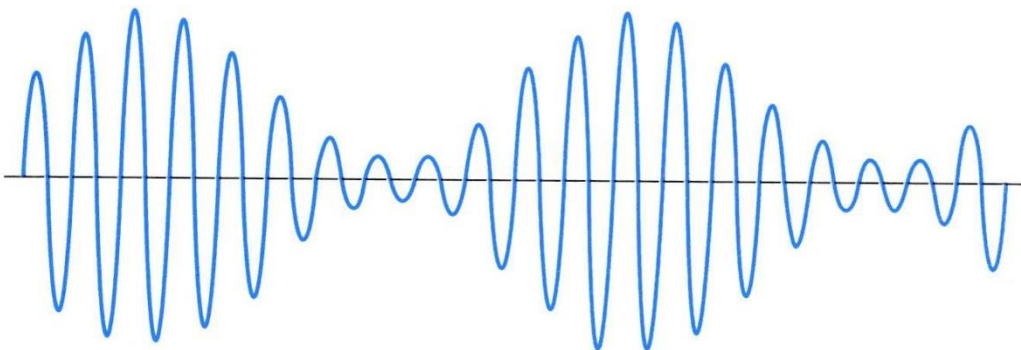
## AM (Amplitude Modulation)



Carrier Signal



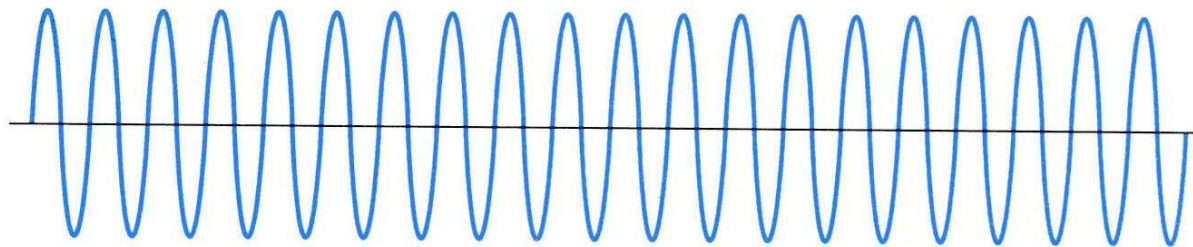
Modulating Sine Wave Signal



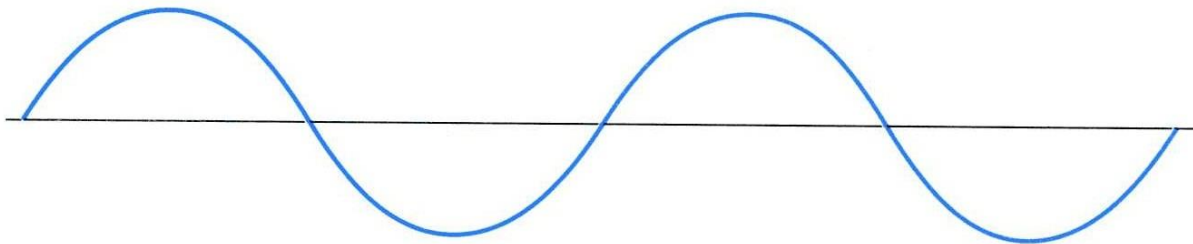
Amplitude Modulated Signal

# Analog Modulation

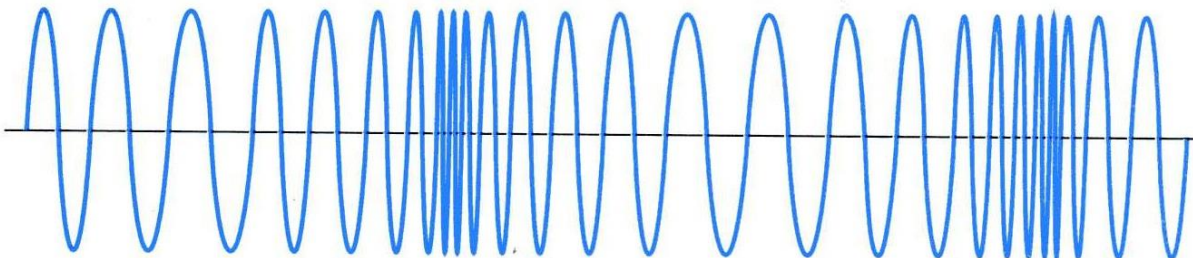
## FM (Frequency Modulation)



Carrier Signal



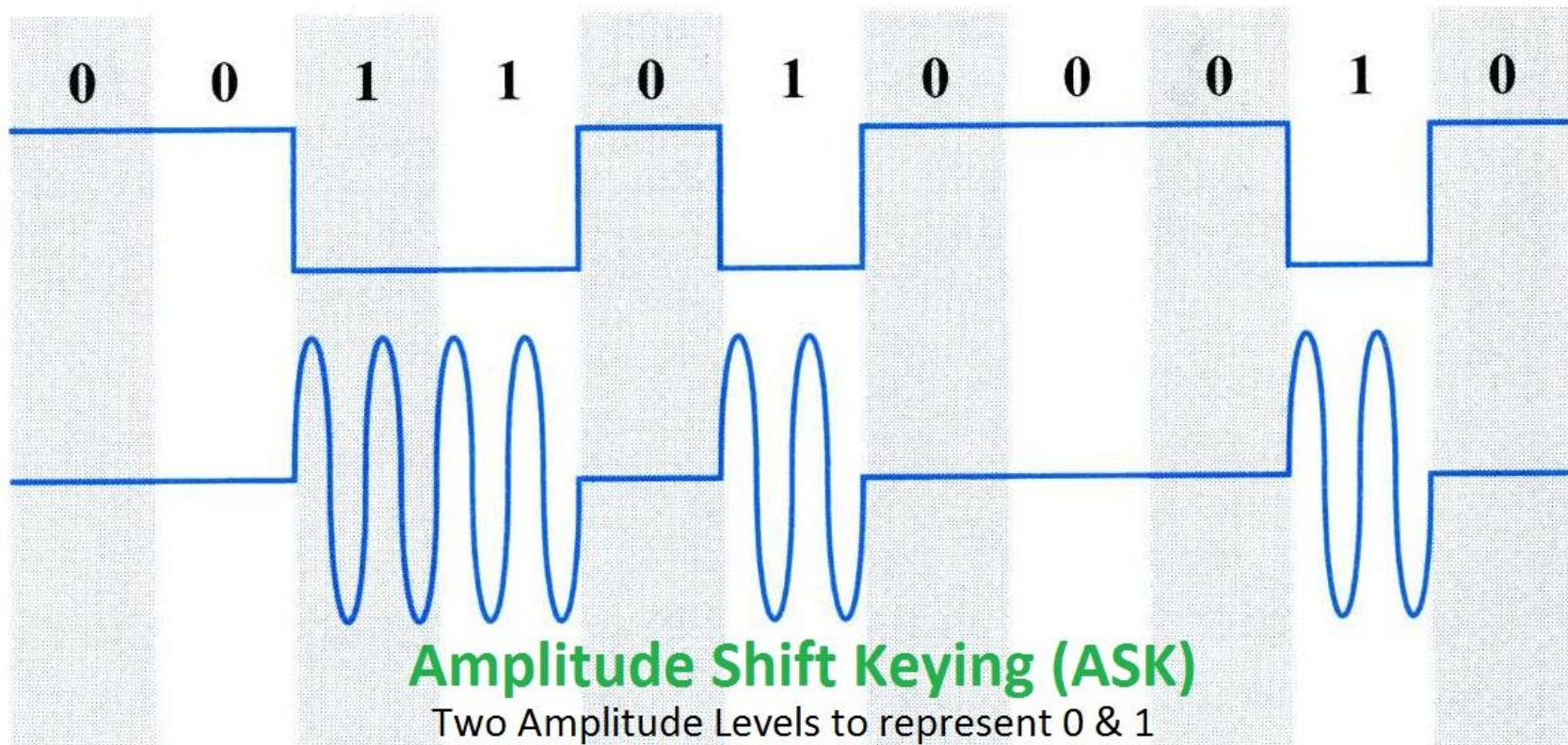
Modulating Sin Wave Signal



Frequency Modulated Signal

# Digital Modulation

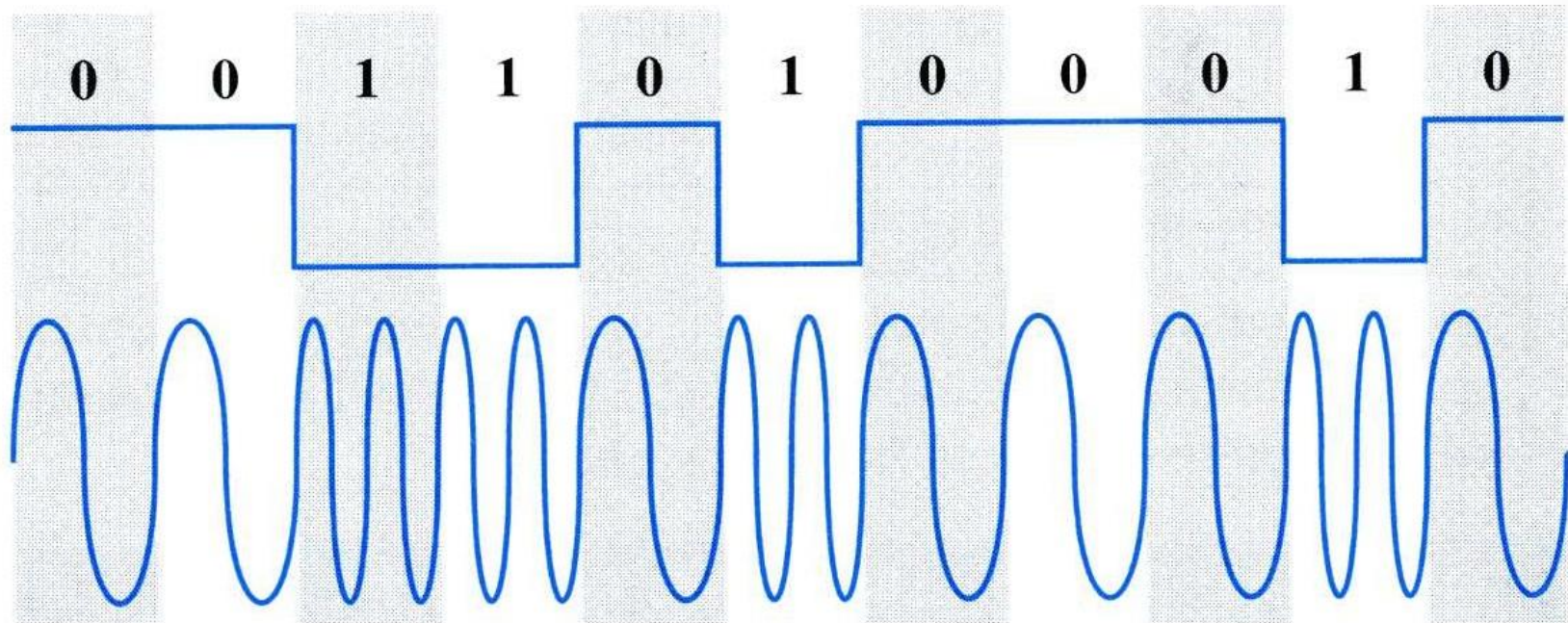
## ASK (Amplitude Shift Keying)





# Digital Modulation

## FSK (Frequency Shift Keying)



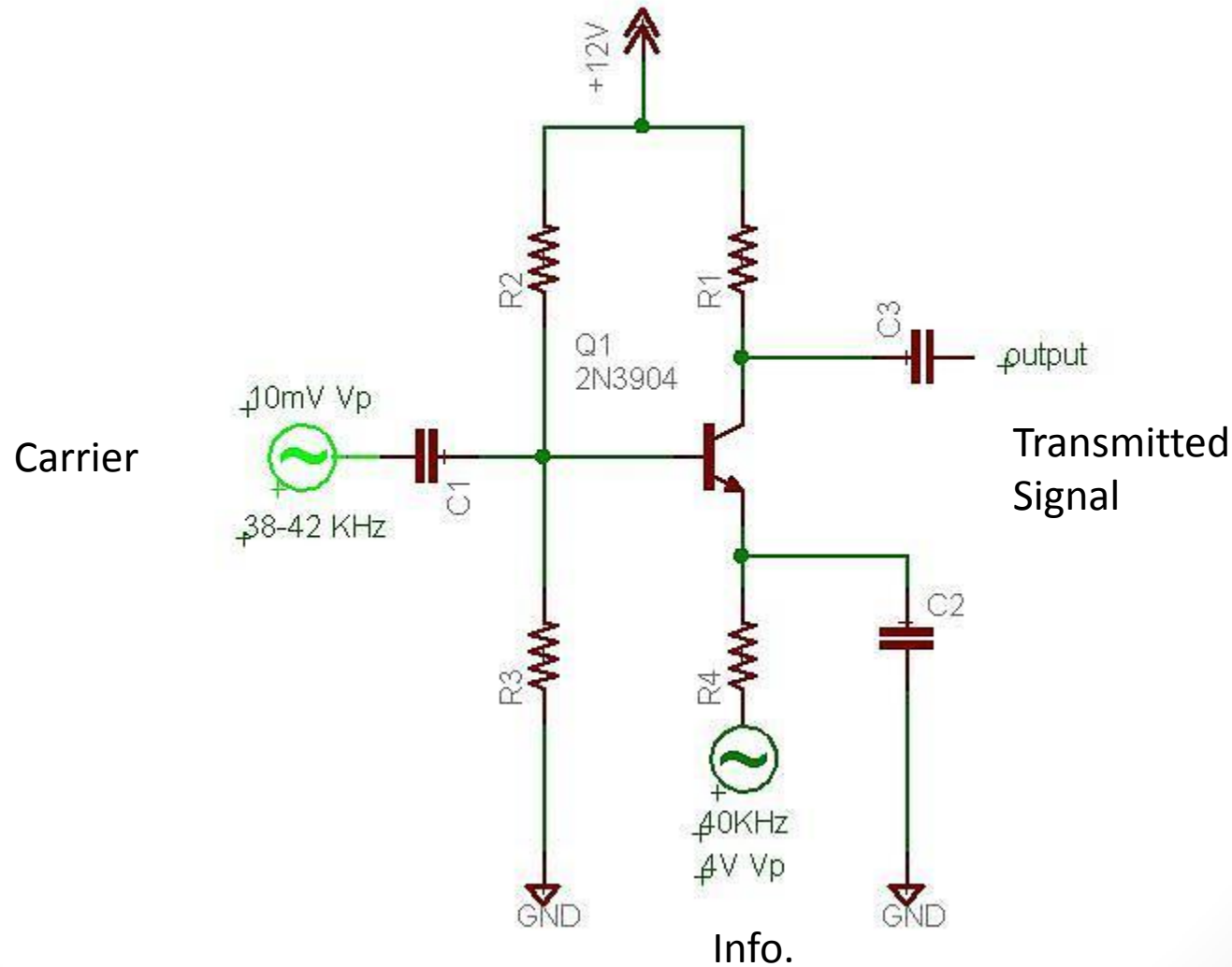
**Frequency Shift Keying (FSK)**

Two frequencies to represent 0 & 1

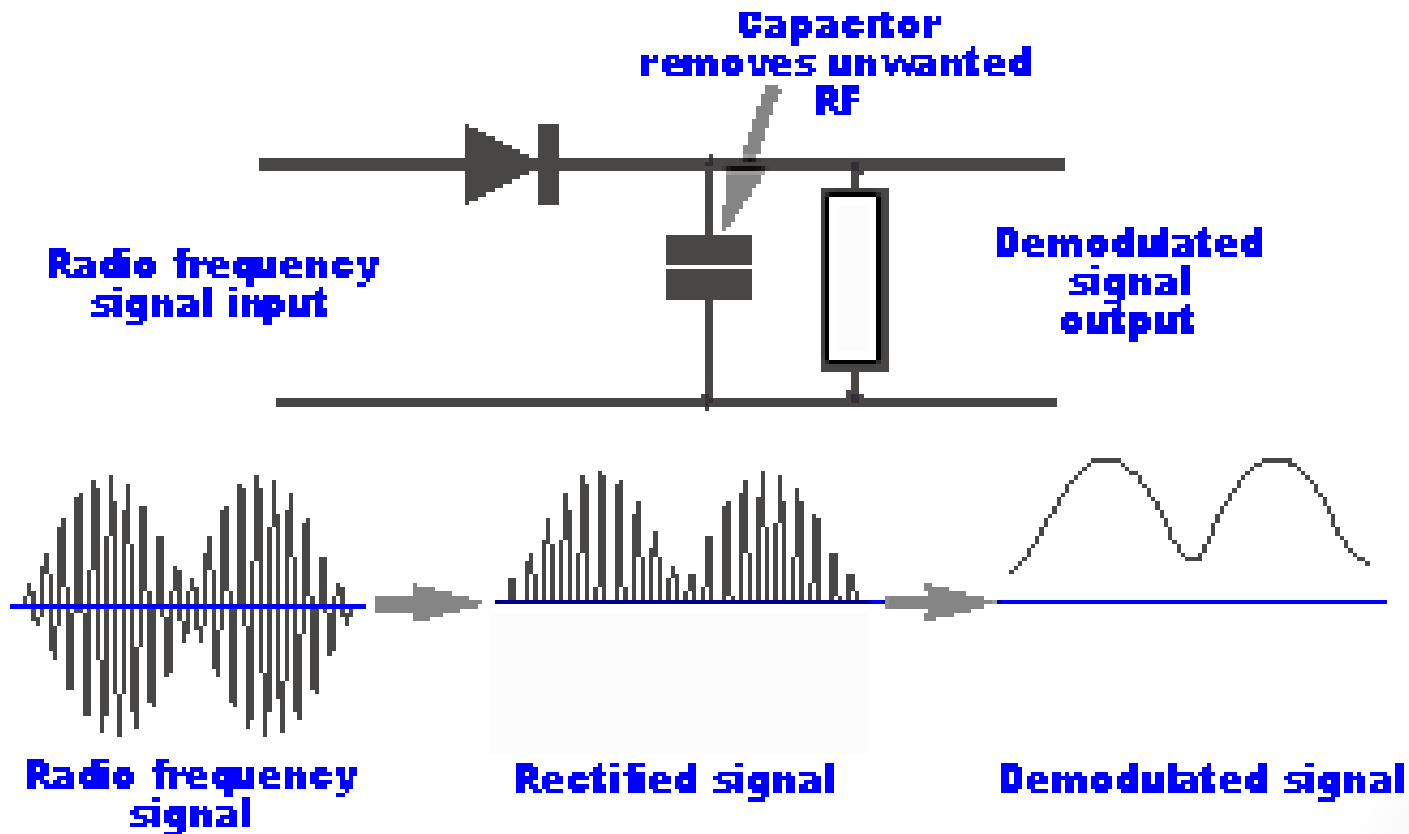
# EXAMPLES OF MODULATION CIRCUITS



# AM Modulator Circuit



# AM Demodulator Circuit





- For more details, refer to:
  - Stallings: **Data Communication**, Chapter 5.2 , found online at <http://ironbark.xtelco.com.au/subjects/DC/lectures/7/>
  - Modulation online Tutorials & wiki.
- The lecture is available online at:
  - <http://bu.edu.eg/staff/ahmad.elbanna-courses/12136>
- For inquires, send to:
  - [ahmad.elbanna@feng.bu.edu.eg](mailto:ahmad.elbanna@feng.bu.edu.eg)