Physical Layer-2
30.09.2019

BLM 3051 Veri İletişimi
(Data Communication)

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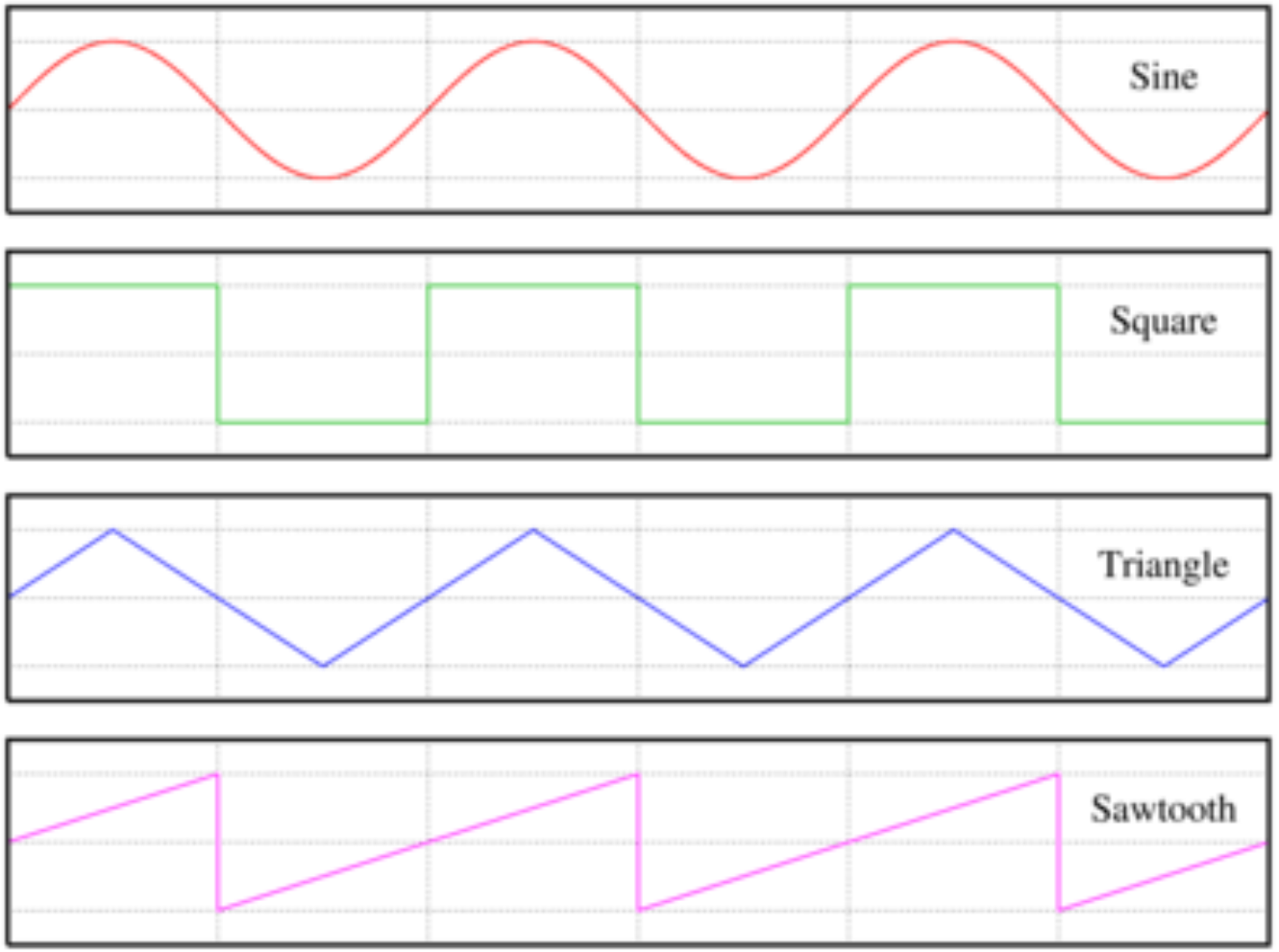
References:

- *Computer Networks*, Andrew Tanenbaum, Pearson, 5th Edition,2010.
- *Computer Networking, A Top-Down Approach Featuring the Internet*, James F.Kurose, Keith W.Ross, Pearson-Addison Wesley, 6th Edition, 2012.
- **BLG 337 Slides** from İTÜ prepared by Assoc. Prof.Dr. Berk CANBERK

Periodic Signals



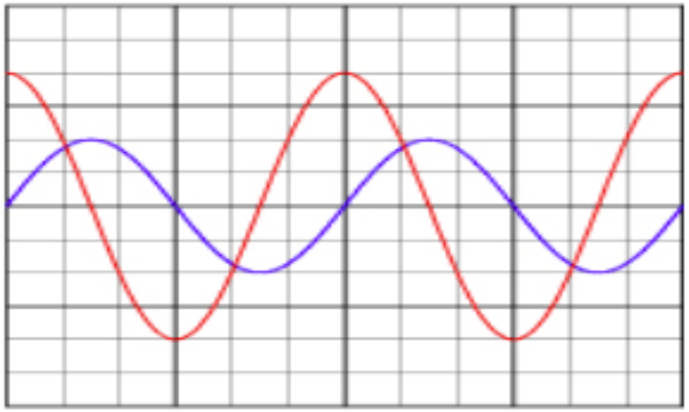
Signal along the channel: ”Sine Wave”

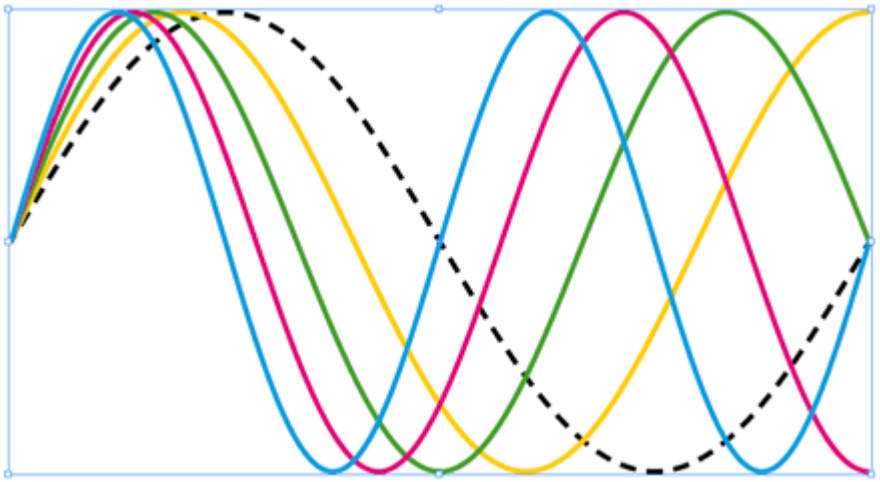
Main properties of the **“Sine Wave”:**

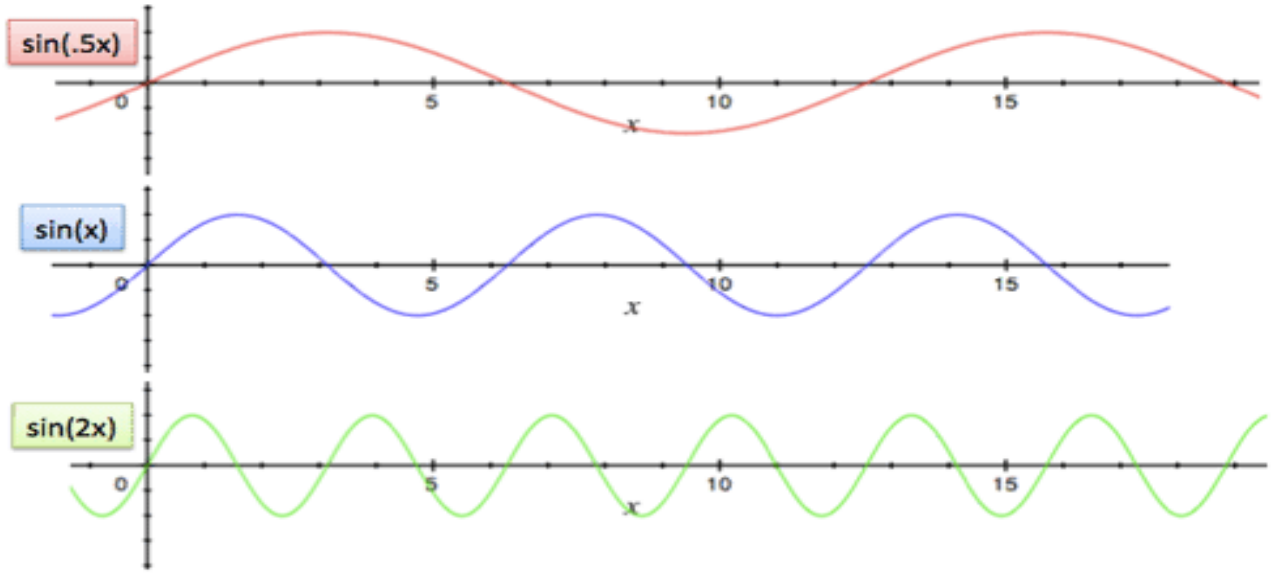
- ✓ **Amplitude**
  - maximum strength of signal
  - volts
- ✓ **Frequency**
  - Rate of change of signal
  - Hertz (Hz) or cycles per second
  - Period = time for one repetition (T)
  - T = 1/f
- ✓ **Phase ( )**
  - Relative position in time, from 0-2*pi
- ✓ **Function**

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

”Sine Wave” Examples





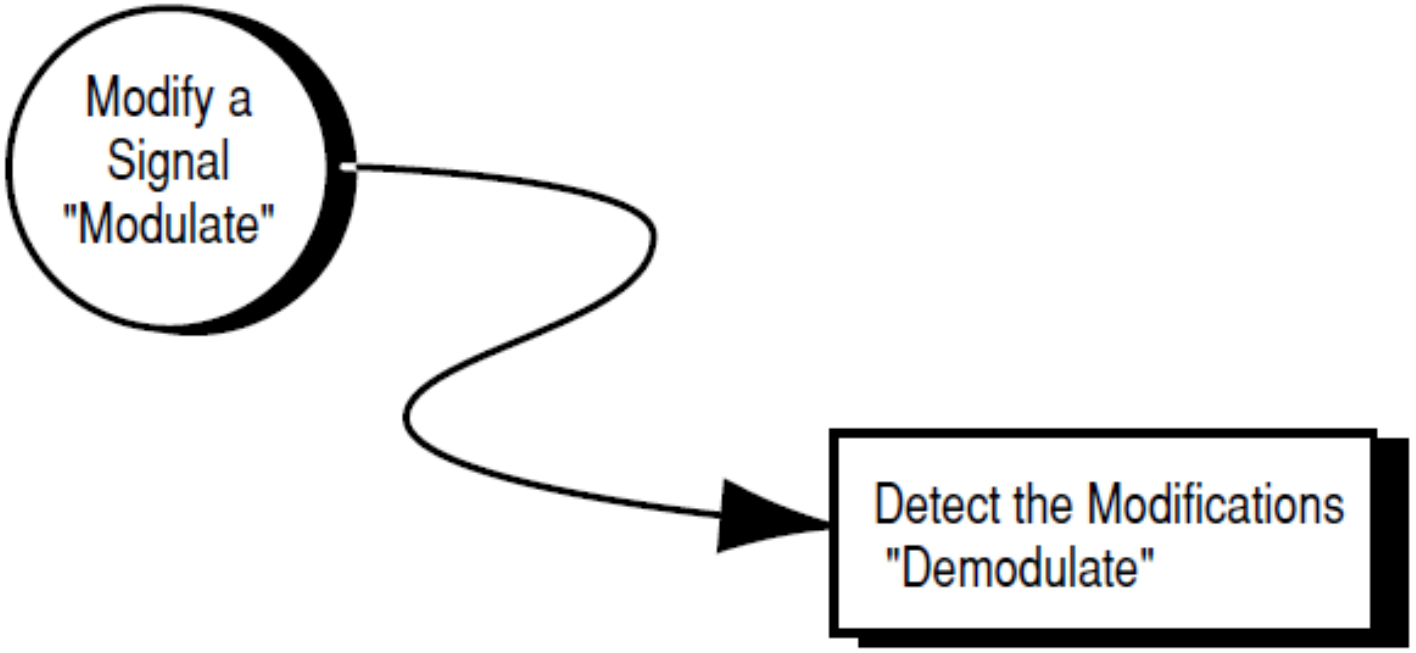


Modulation - Demodulation

- The sine wave on which the characteristics of the information signal are modulated is called a **carrier signal**

- **Modulation** = Adding information to a carrier signal
- **Demodulation** = Extracting the original information from the carrier signal

Modulation - Demodulation

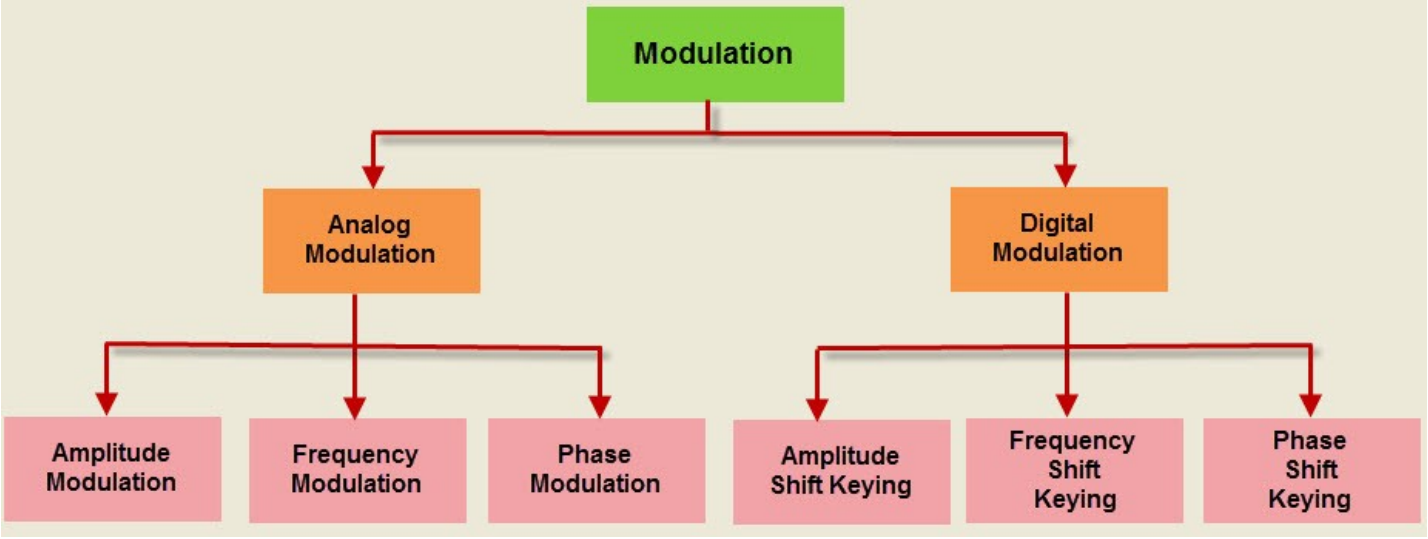


Any reliably detectable change in
signal characteristics can carry information

Modulation - Demodulation

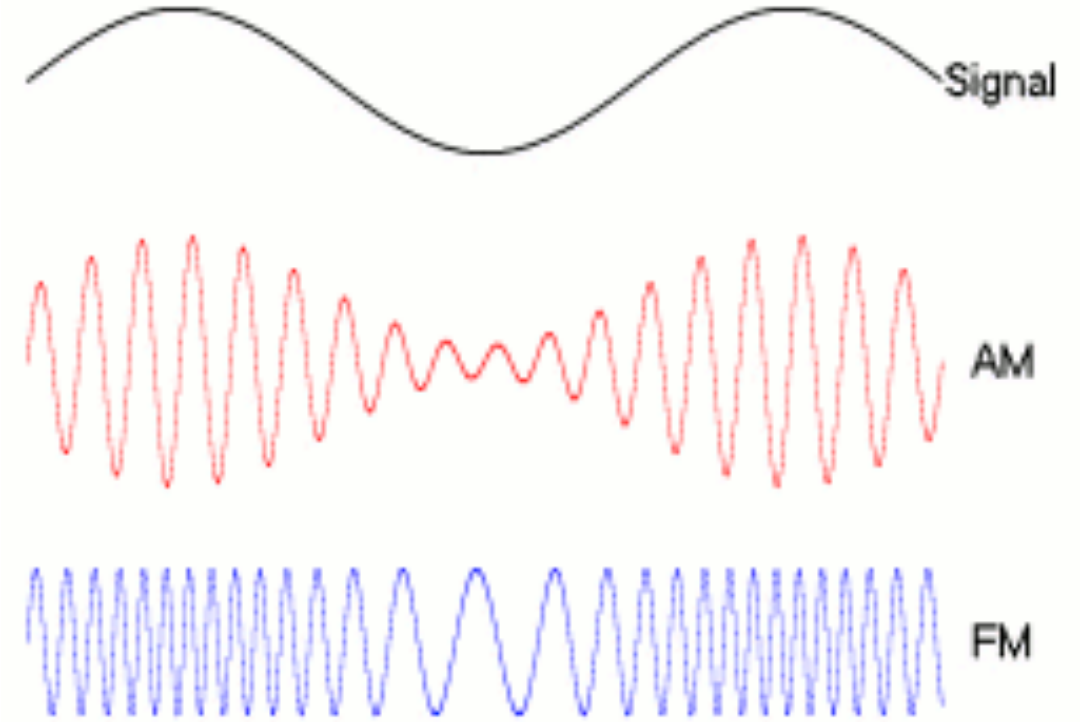
- ✓ Modulation is the general technique of shaping a signal to convey information.

- ✓ There are two types of modulation:
  - Analog Modulation
  - Digital Modulation



Analog Modulation

In contrast to digital modulation, where an analogue signal is transmitted over an analogue channel, and where the modulated analogue signal will have an infinite number of meaningful states.

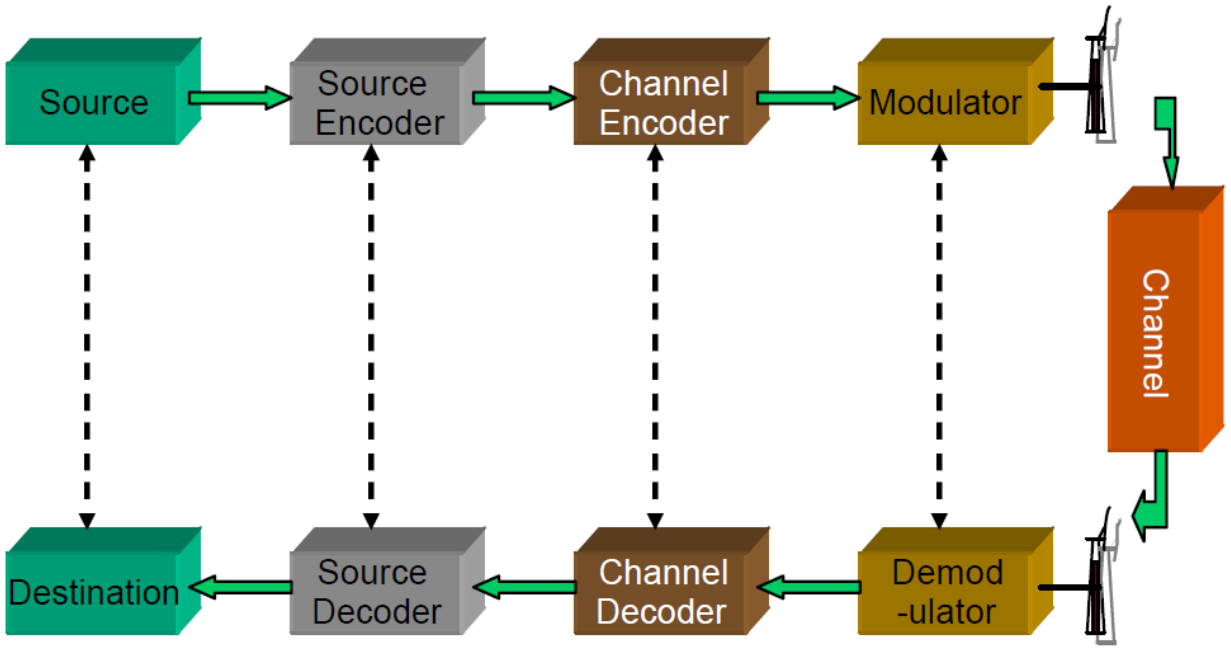


Digital Modulation

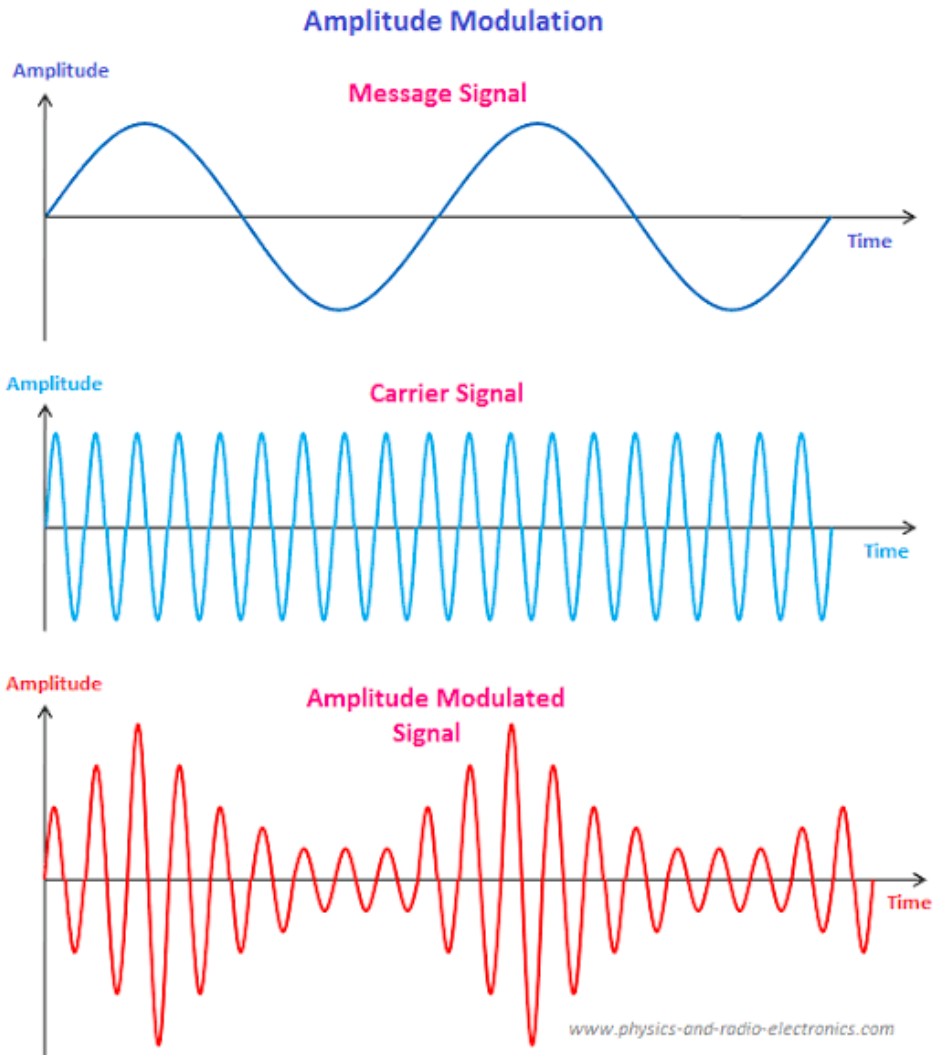
- When a digital message has to be represented as an analog waveform, the technique and term keying (or digital modulation) is used.
- **Keying is a family of modulation forms where the modulating signal takes one of a specific (predetermined) number of values at all times.**
- The goal of keying is to transmit a digital signal over an analog channel. The name derives from the Morse code key used for telegraph signaling.
- **Keying is characterized by the fact that the modulating signal will have a limited number of states (or values) at all times, to represent the corresponding digital states (commonly zero and one, although this might depend on the number of symbols used).**

Modulation Criteria

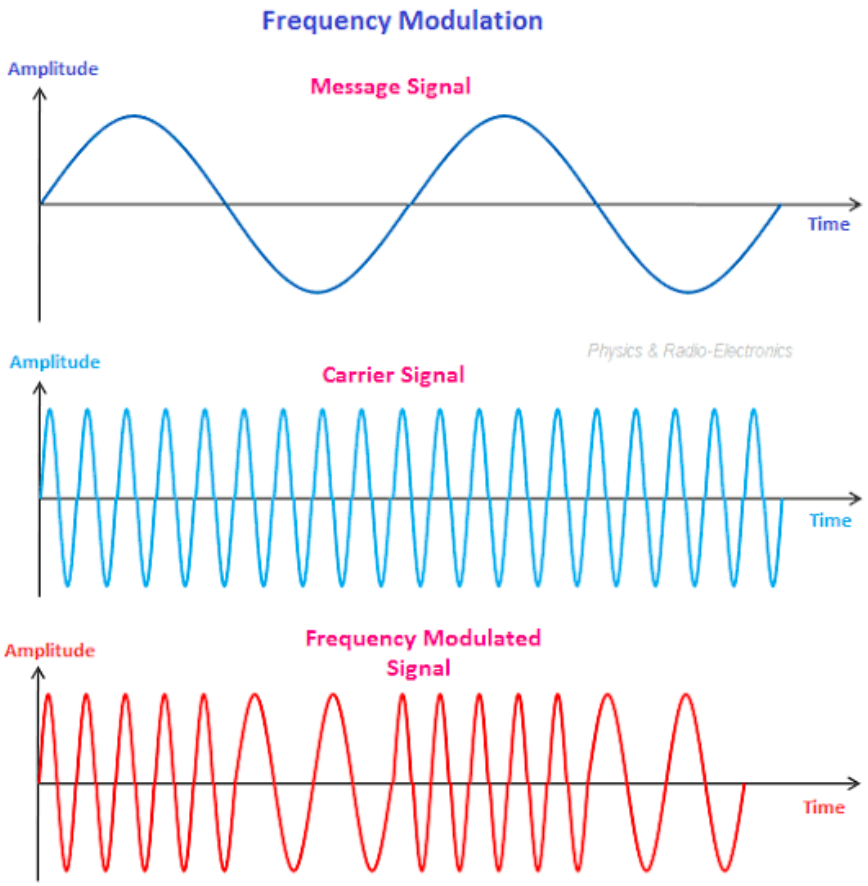
- ✓ Digital modulation can be done by using the three features of the carrier signal
  - amplitude
  - frequency
  - phase



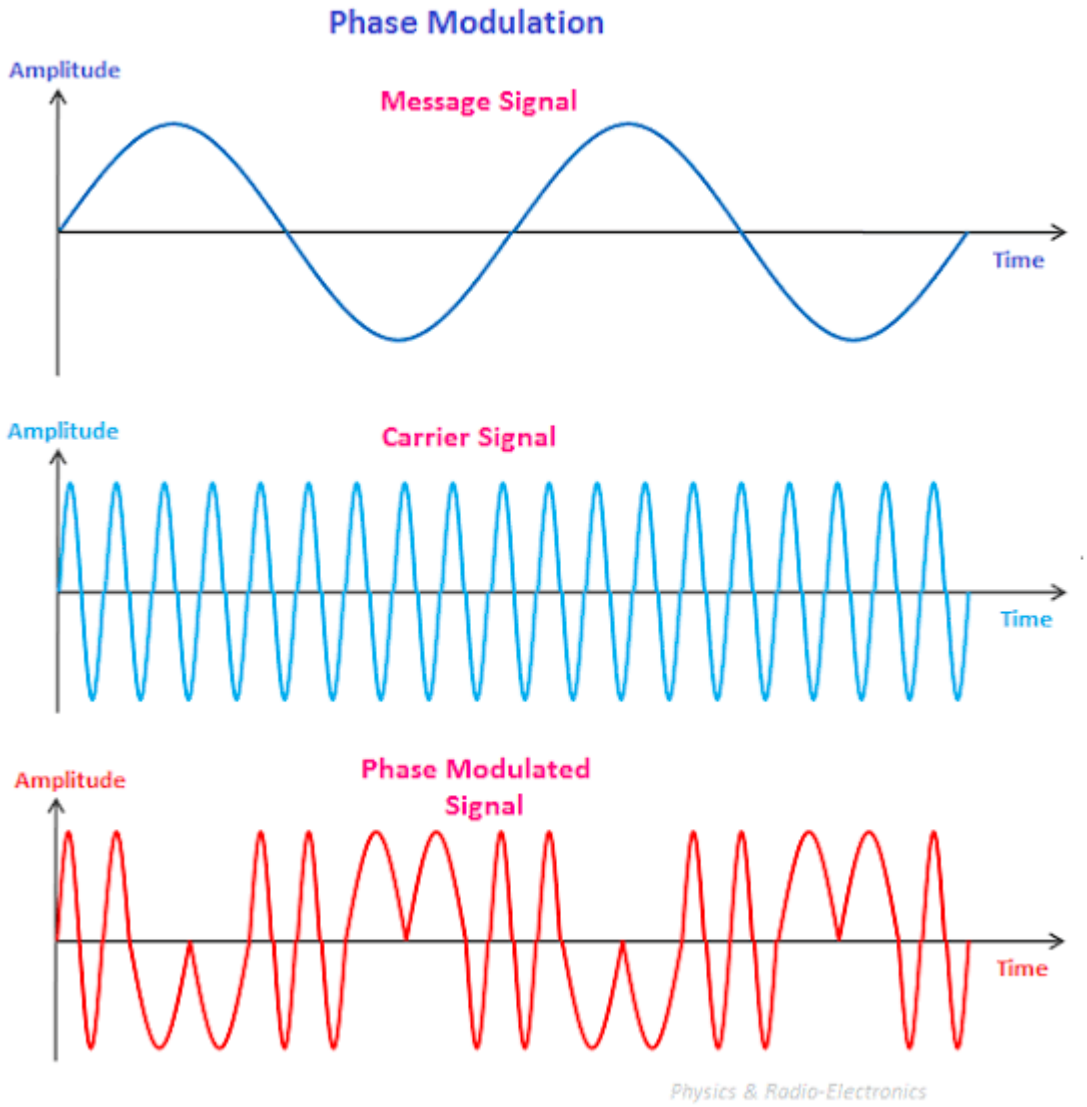
Modulation Types: AM



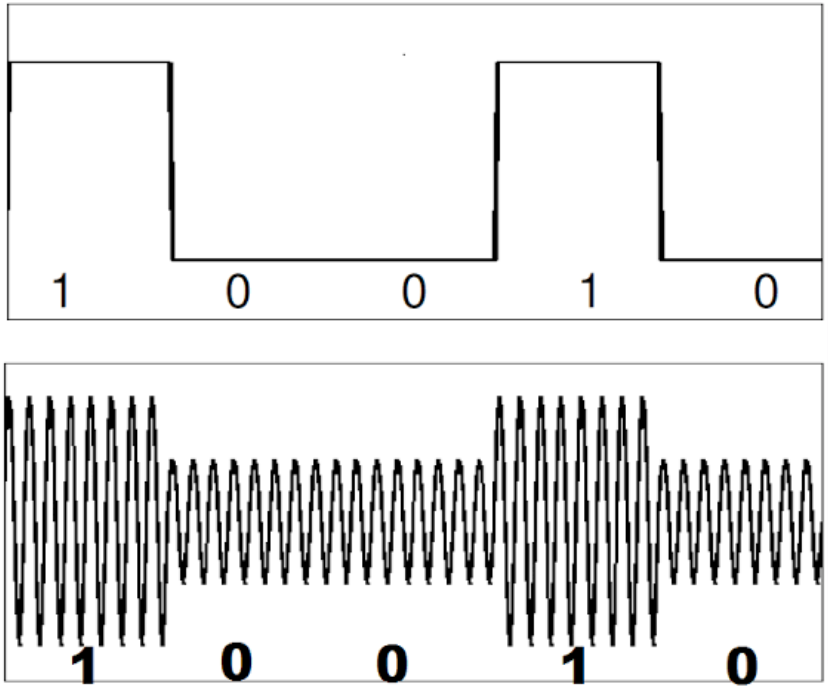
Modulation Types: FM

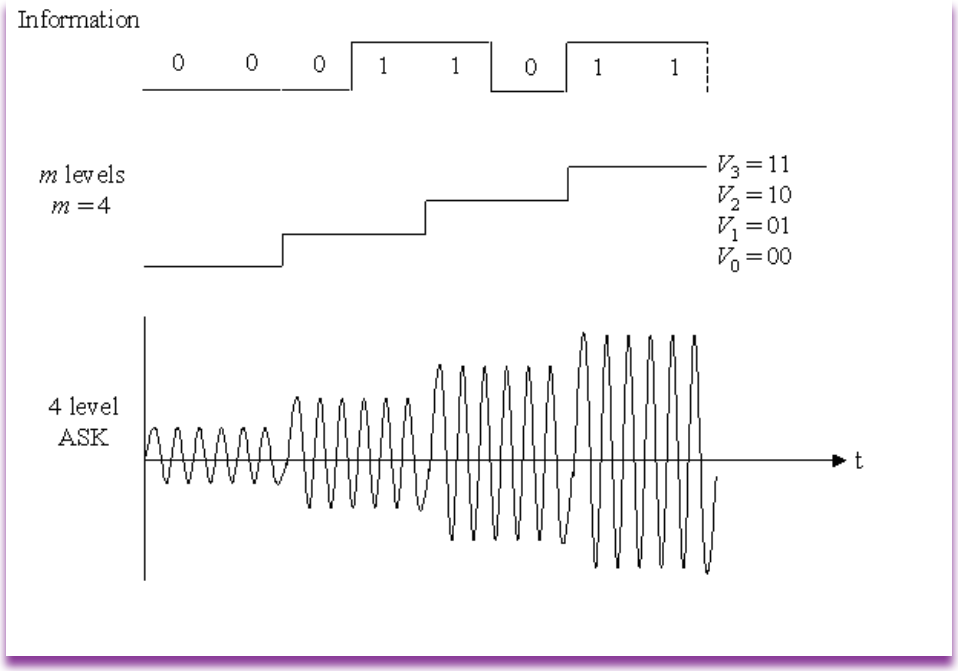


Modulation Types: PM

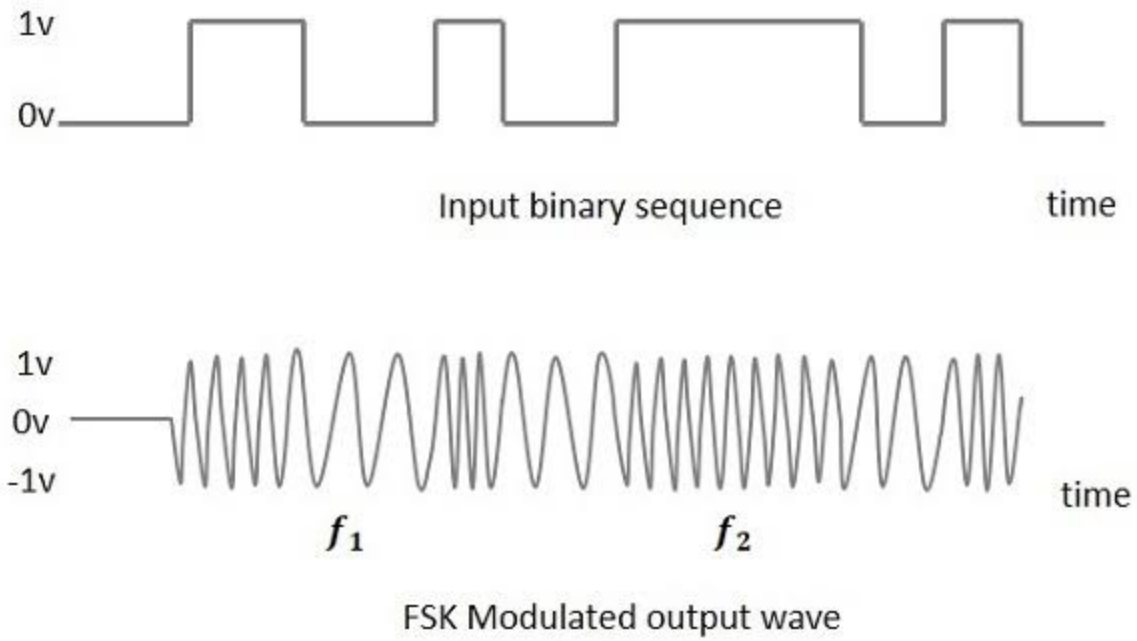


Modulation Types: ASK

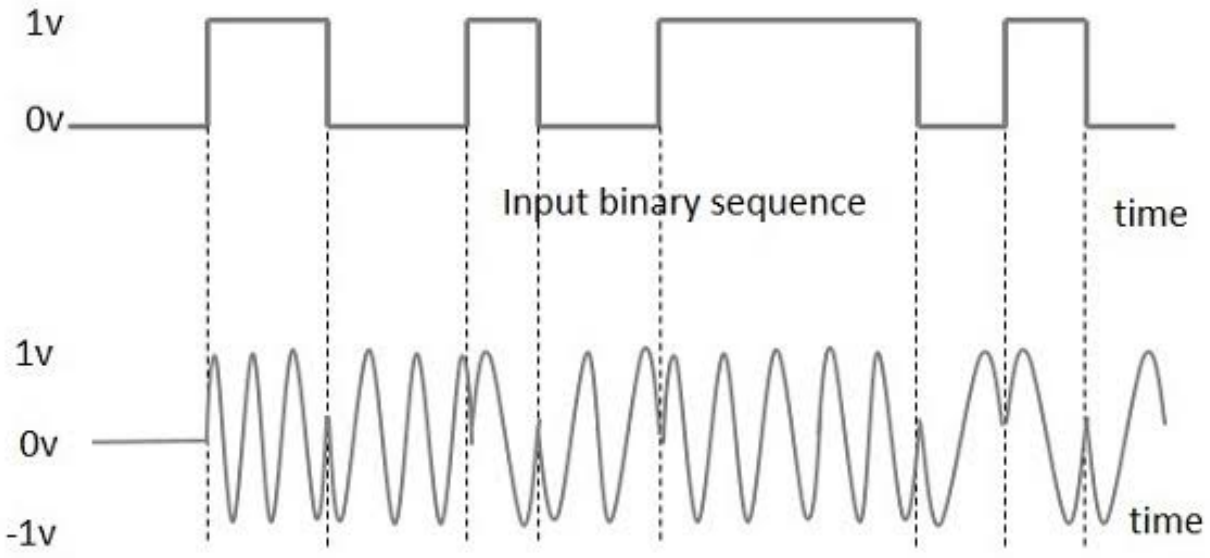




Modulation Types: FSK



Modulation Types: PSK



BPSK Modulated output wave

Amplitude modulation

- ✓ The transmitter just uses the information signal, Vm(t) to vary the amplitude of the carrier, Vco, to produce a modulated signal, VAM(t).
- ✓ In mathematical form:
  - Information: Vm(t)
  - Carrier: Vc(t) = Vco sin (2 p fc t + f)

AM: VAM(t) = { Vco + Vm(t) }sin (2 p fc t + f)

- ✓ the amplitude term has been replaced by the combination of the original amplitude plus the information signal.

Amplitude modulation

- ✓ The amount of the modulation is formulated as:
  - **Modulation Index m = MAX(Vm(t))/ Vco.**
  - **Modulation Index m = Vmo/Vco.(the info signal is a sine wave)**

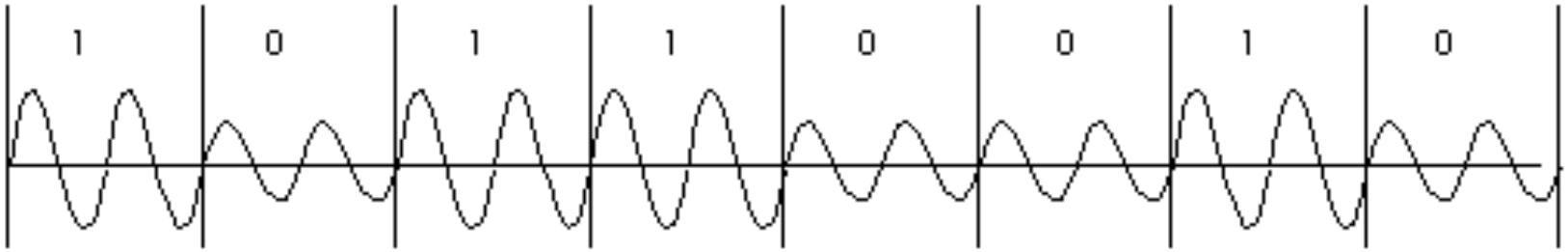
- ✓ If m =0.5, the carrier amplitude varies by 50 % above and below its original value. If m= 1.0 then it varies by 100%.

Digital Modulation

- ✓ Amplitude Shift Keying
- ✓ Frequency Shift Keying
- ✓ Phase Shift Keying

Amplitude Shift Keying (ASK)

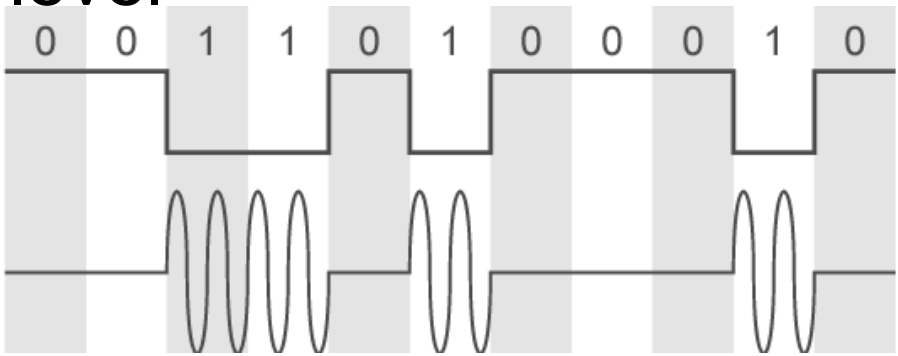
- ✓ ASK represents each of the amplitude level as each of the bit sequence.
- ✓ The number of used bits that represents each of the level is equal to product of 2 whose product is equal to number of different levels of amplitude.
- ✓ AM is more sensitive to noise than other modulation techniques => AM is not widely used in data transmission



Amplitude Shift Keying (ASK)

- ✓ The formulation of the sine wave for the simple two different amplitude level

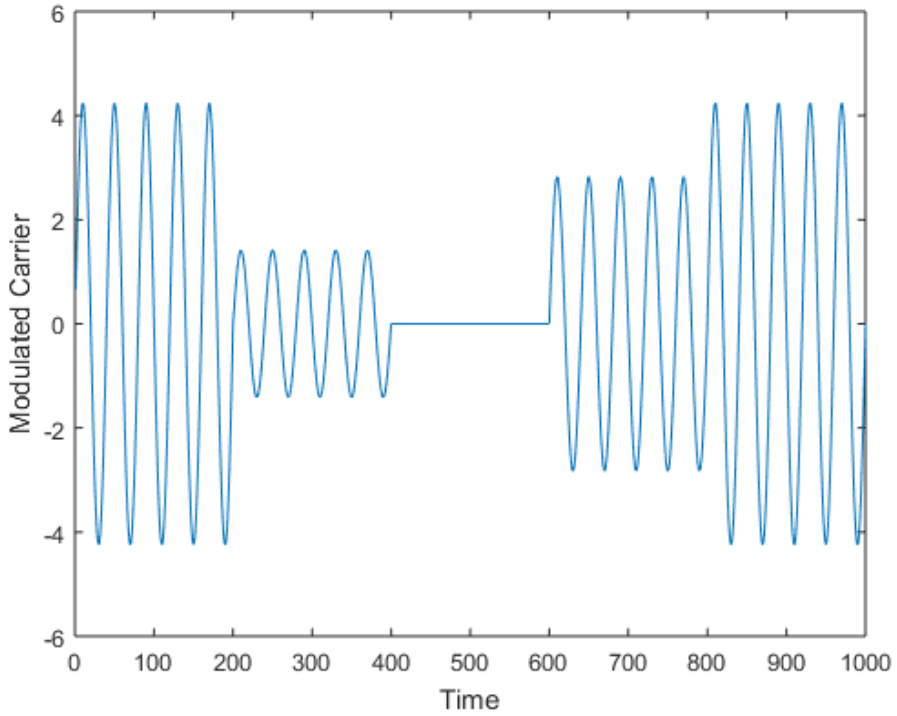
$$s(t) = \begin{cases} A\cos(2\pi f_c t), & binary\ 1 \\ 0, & binary\ 0 \end{cases}$$

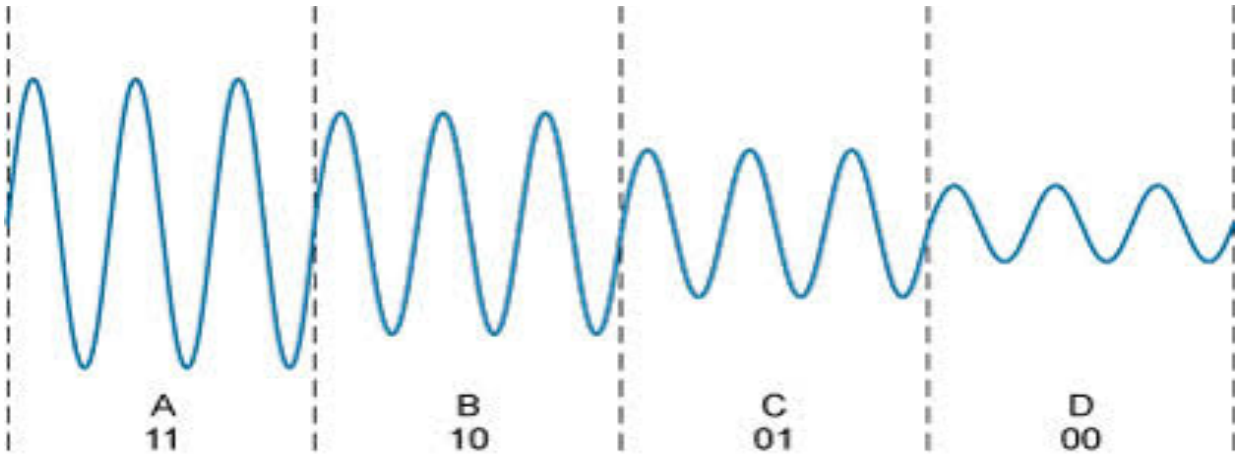


(a) ASK

- ✓ Weak to noise
- ✓ Inefficient modulation technique
- ✓ Usage Area:
  - up to 1200bps on voice grade lines
  - very high speeds over optical fiber

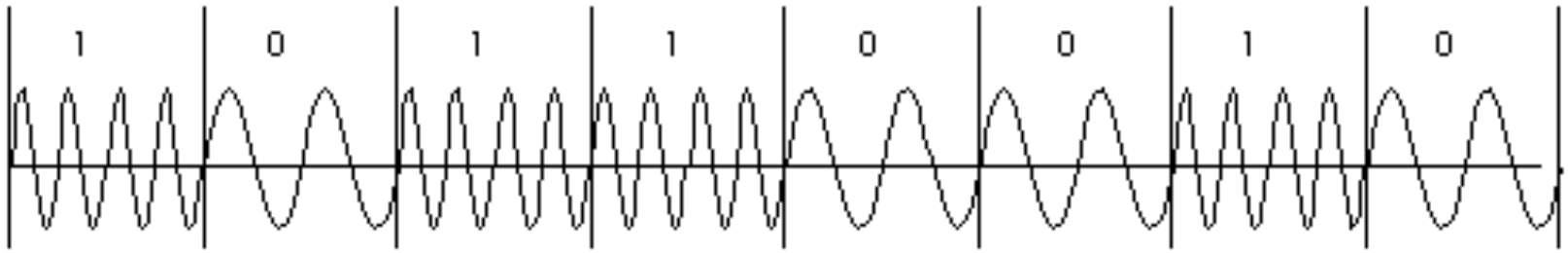
Amplitude Shift Keying (ASK)





Frequency Shift Keying (FSK)

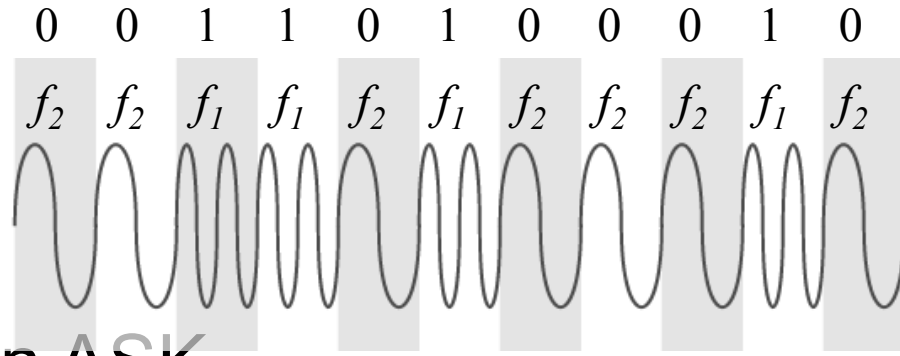
- ✓ FSK represents each of the sine wave with different frequencies as different bits or bit sequences.
- ✓ The number of used bits that represents each of the level is equal to product of 2 whose product is equal to number of different frequencies.
- ✓ FSK is less weak sensitive to noise than ASK = Many modems use FSK to convert digital data to analogue signals.



Binary Frequency Shift Keying (BFSK)

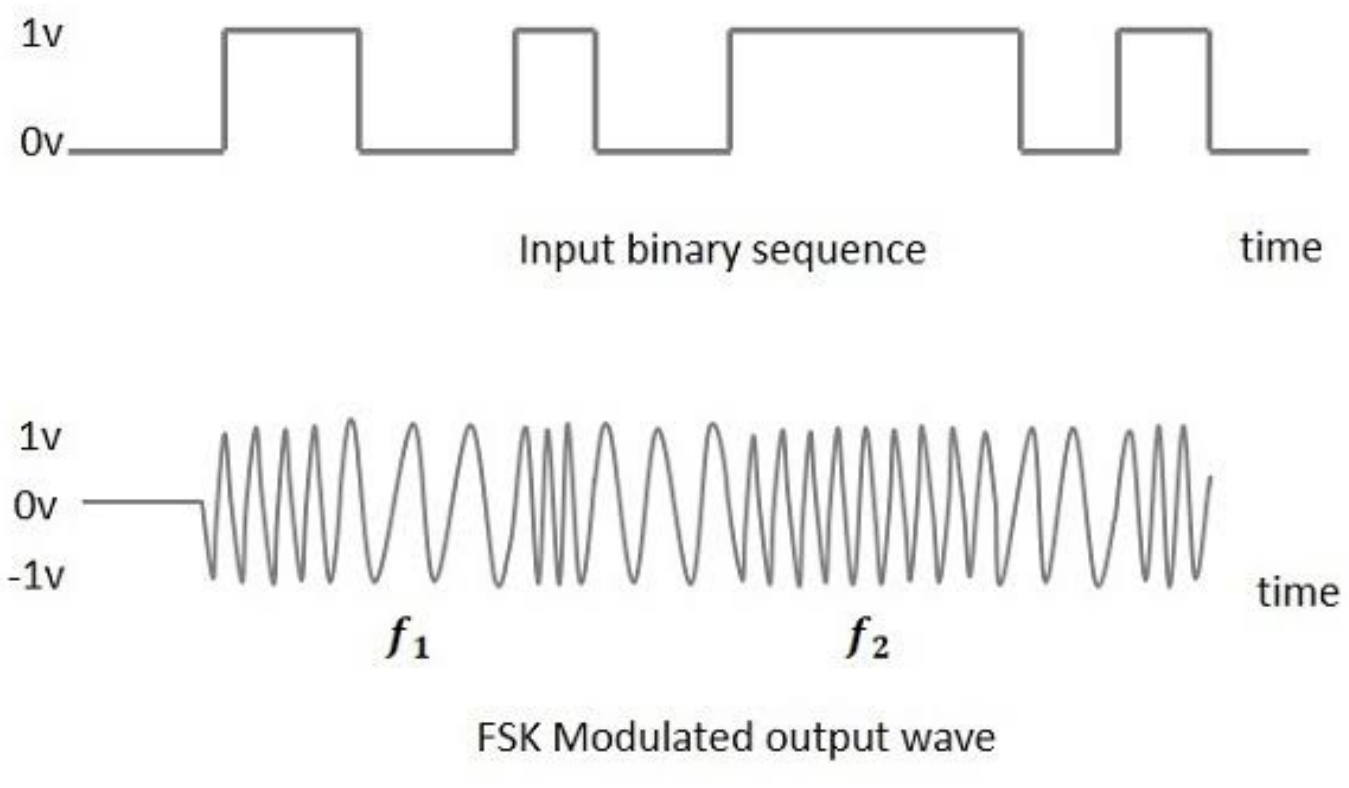
- ✓ The formulation of the sine wave for the simple two different frequencies (f_1 and f_2)

$$s(t) = \begin{cases} A\cos(2\pi f_1 t), & binary\ 1 \\ A\cos(2\pi f_2 t), & binary\ 0 \end{cases}$$



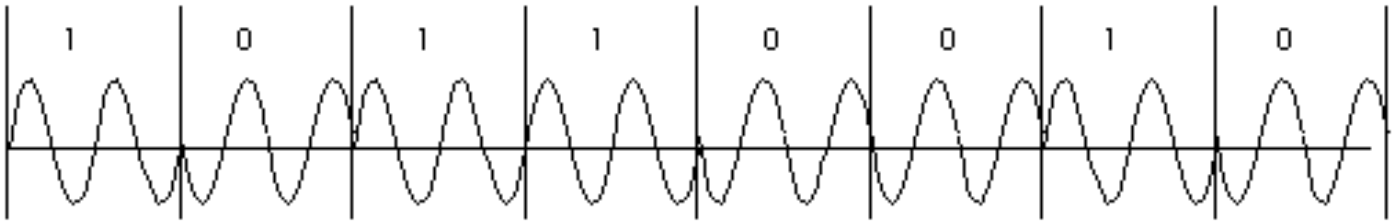
- ✓ Less weak to noise than ASK
- ✓ Inefficient modulation technique
- ✓ Usage Area:
  - up to 1200bps on voice grade lines
  - high frequency radio (3 to 30MHz)
  - even higher frequency on LANs using coaxial cable

Frequency Shift Keying (FSK)



Phase Shift Keying (PSK)

- ✓ PSK. represents each of the sine wave with different phase level as each of the bit sequence.
- ✓ The number of used bits that represents each of the level is equal to product of 2 whose product is equal to number of each of the sine wave with different phase levels.
- ✓ PSK is highly strong to noise.



Phase Shift Keying (PSK)

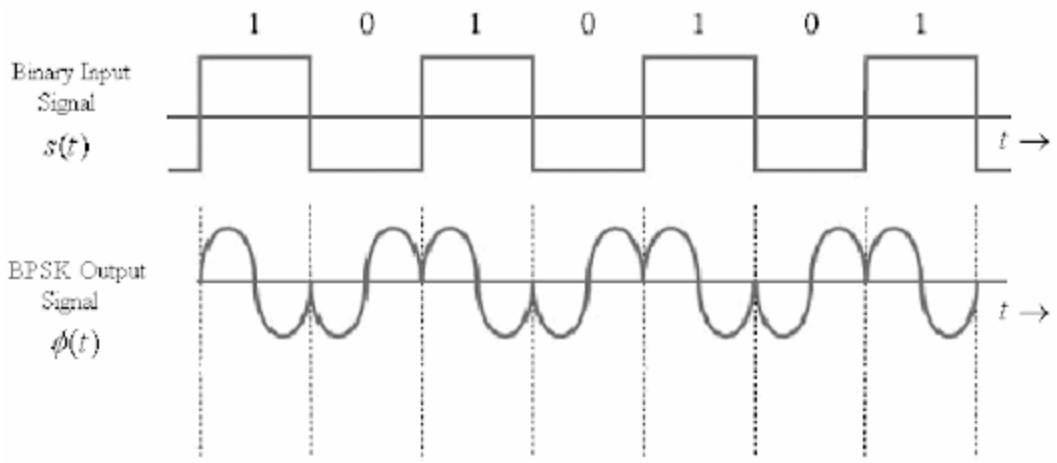
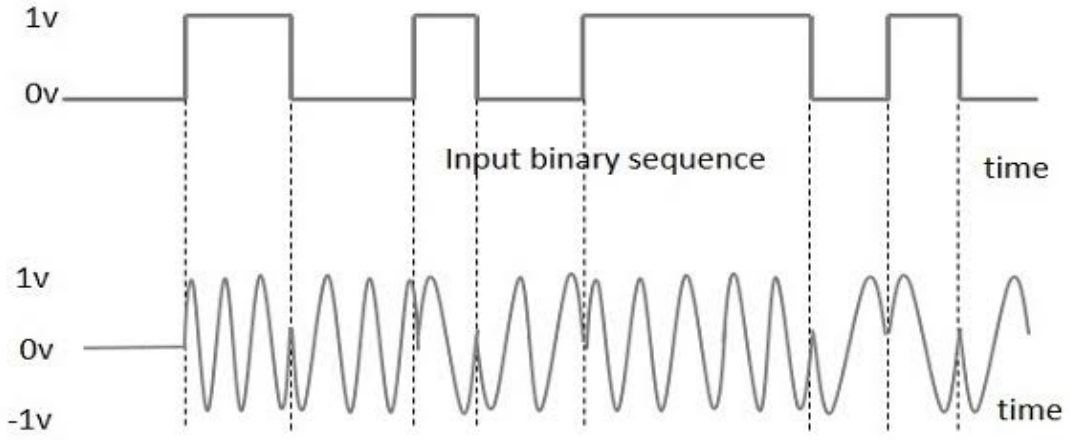


Figure – 2. Input Signal and BPSK Output

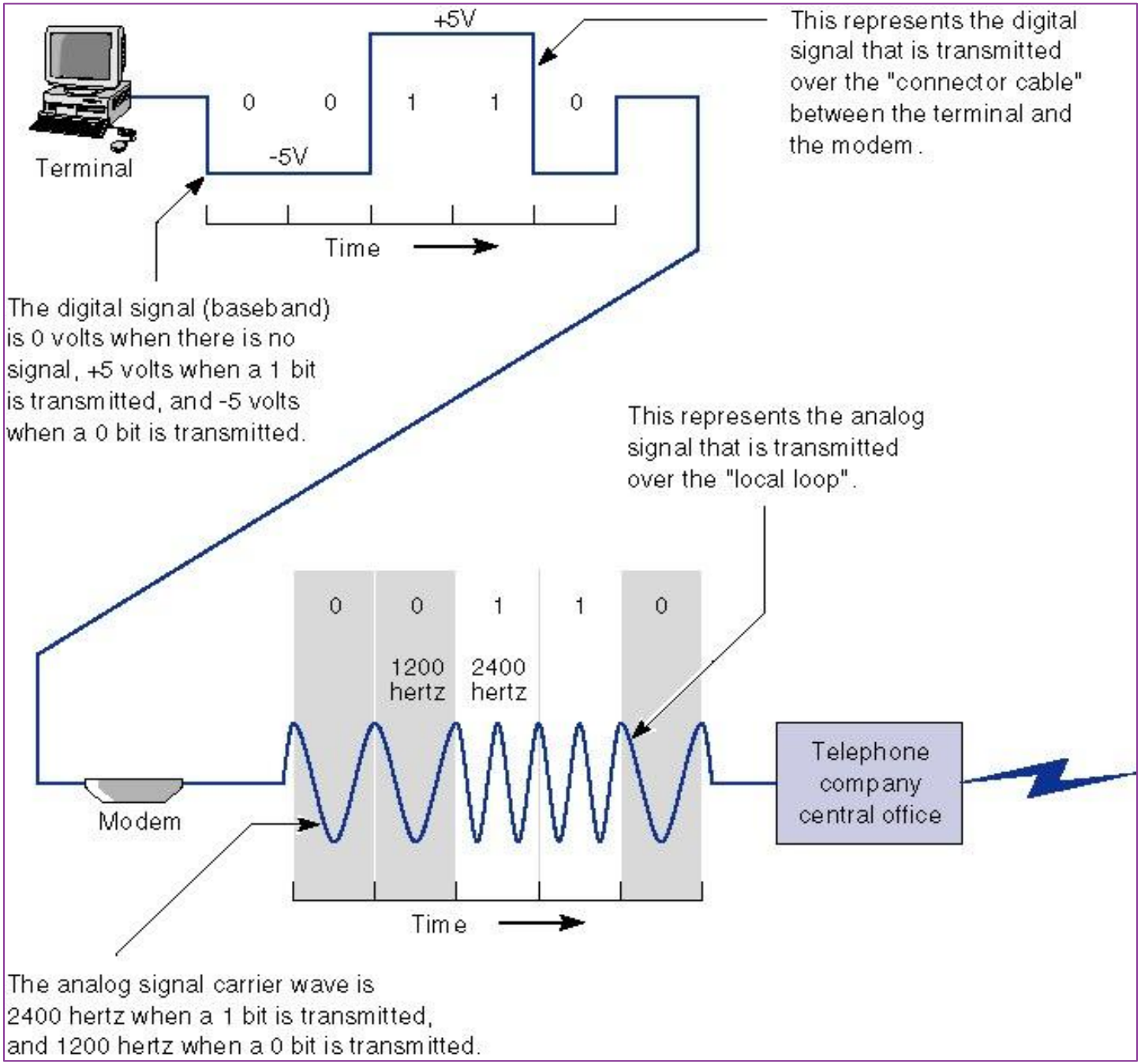


BPSK Modulated output wave

Demodulation

- ✓ Demodulation is the process of extracting the digital information from the analog carrier signal.
- ✓ By means of demodulation and modulatıon, long distance communcation systems can use the advantage of the less attenuation by analog carrier signal than digital.

Demodulation

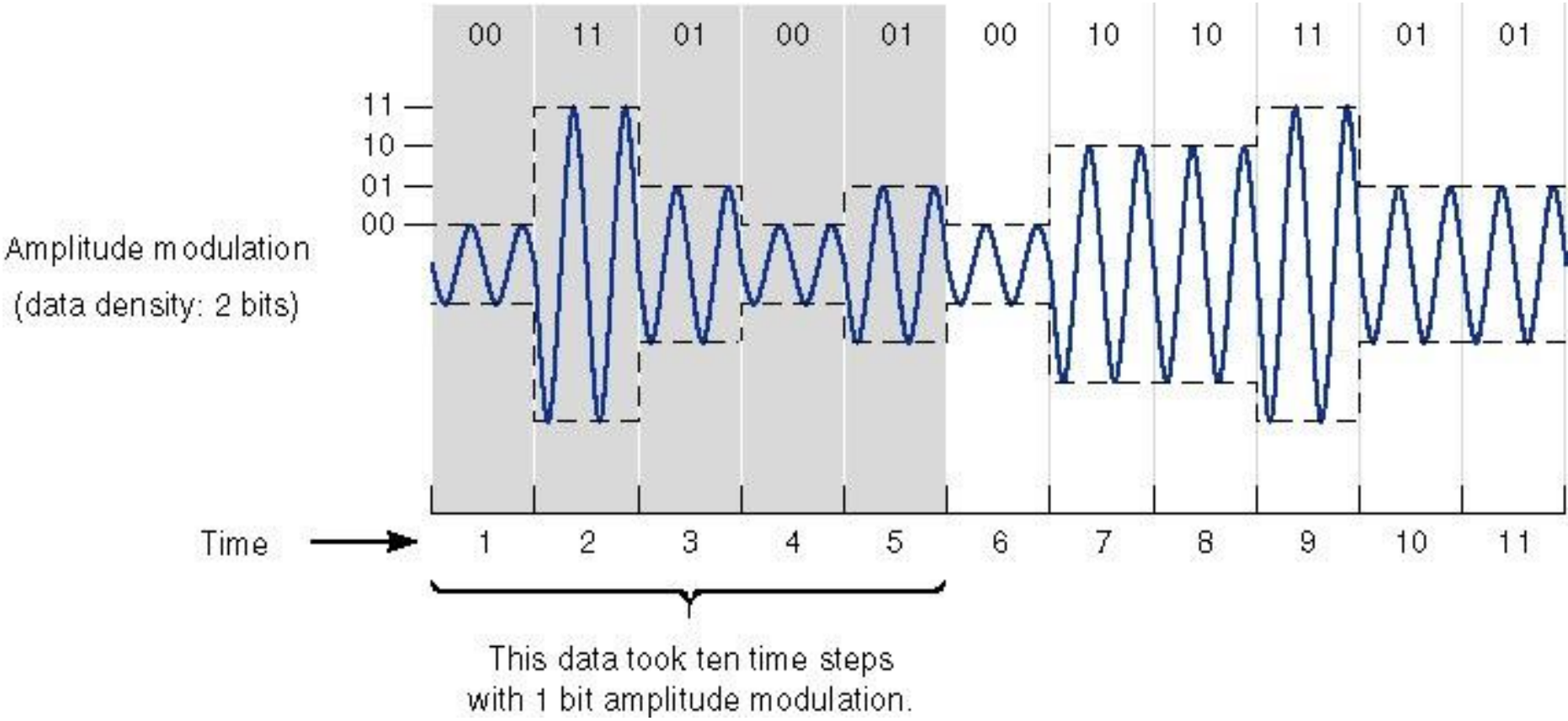


Hybrid Ideas of Modulation

- ✓ It is possible to send more than one bit at a time by using one of the modulation techniques.
  - Two bits can be send at a time by using 4 different amplitudes with ASK.

- ✓ The number of bits could be increased by using different amplitudes and different frequencies at at the same time.

Hybrid Ideas of Modulation



Hybrid Ideas of Modulation