BLG 337E- Principles of Computer Communications

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-Physical Layer(2)-

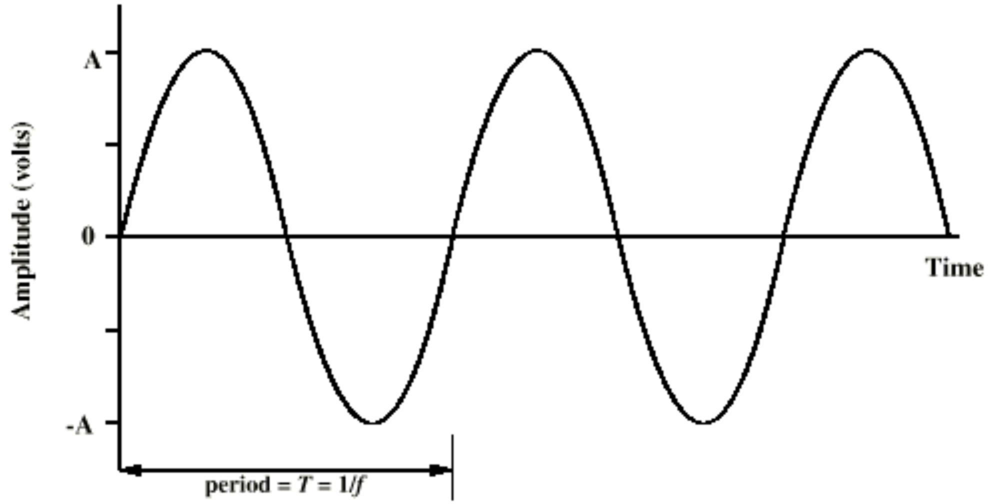
References:

Data and Computer Communications, William Stallings, Pearson-Prentice Hall, 9th Edition, 2010.

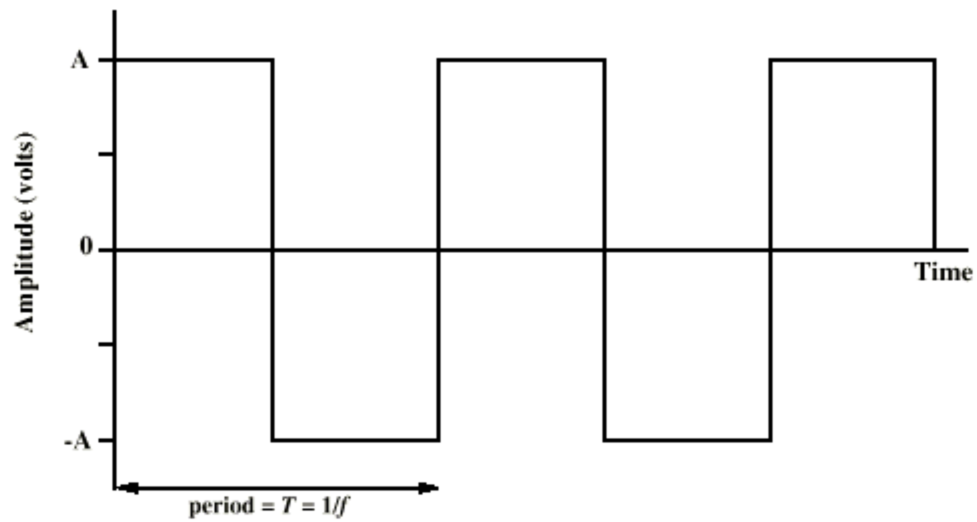
-*Computer Networking, A Top-Down Approach Featuring the Internet*, James F.Kurose, Keith W.Ross, Pearson-Addison Wesley, 6th Edition, 2012.

-Google!

Periodic Signals



(a) Sine wave



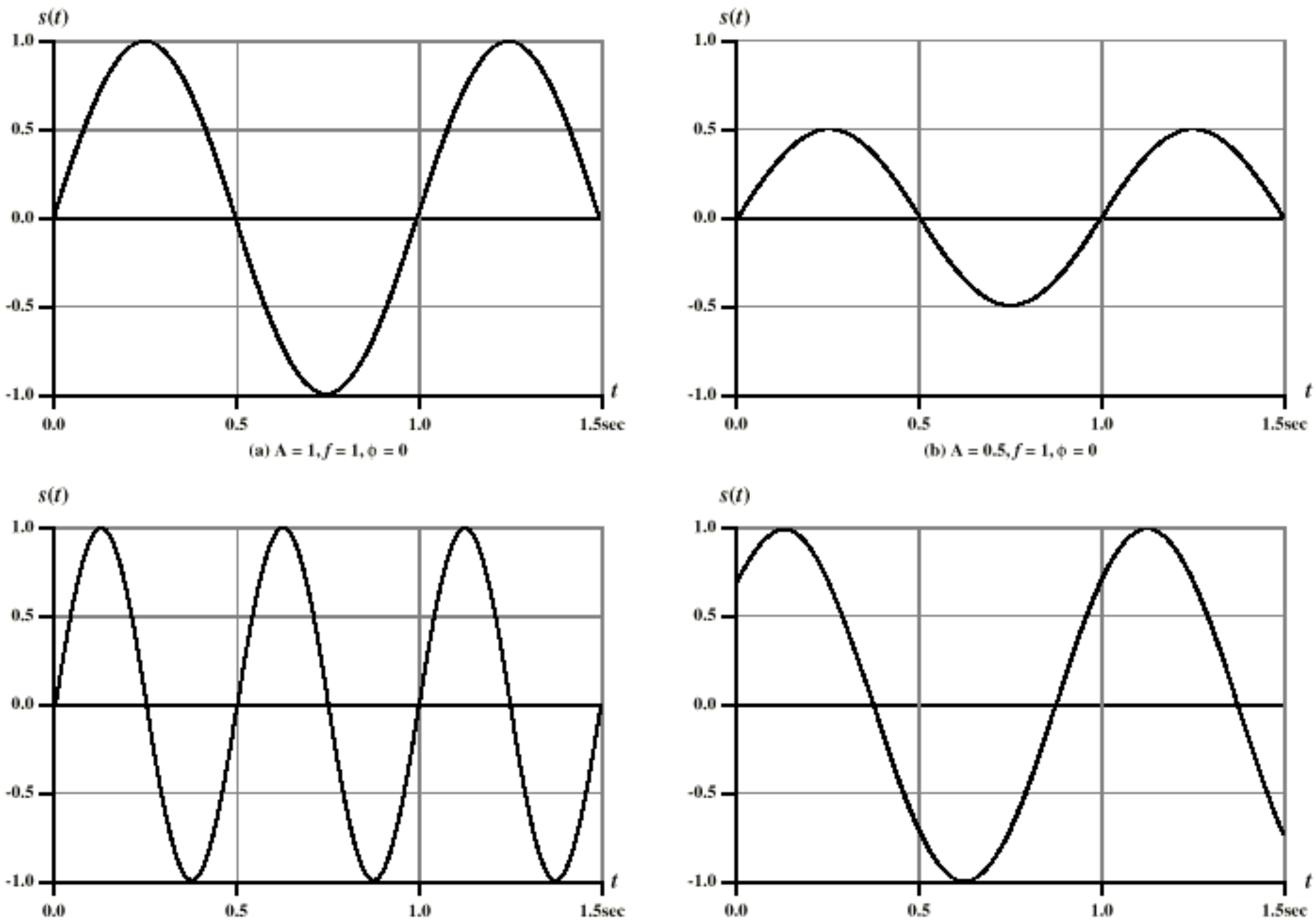
(b) Square wave

Sine Wave

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

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

Varying Sine Waves



(a) A = 1, f = 1, ϕ = 0

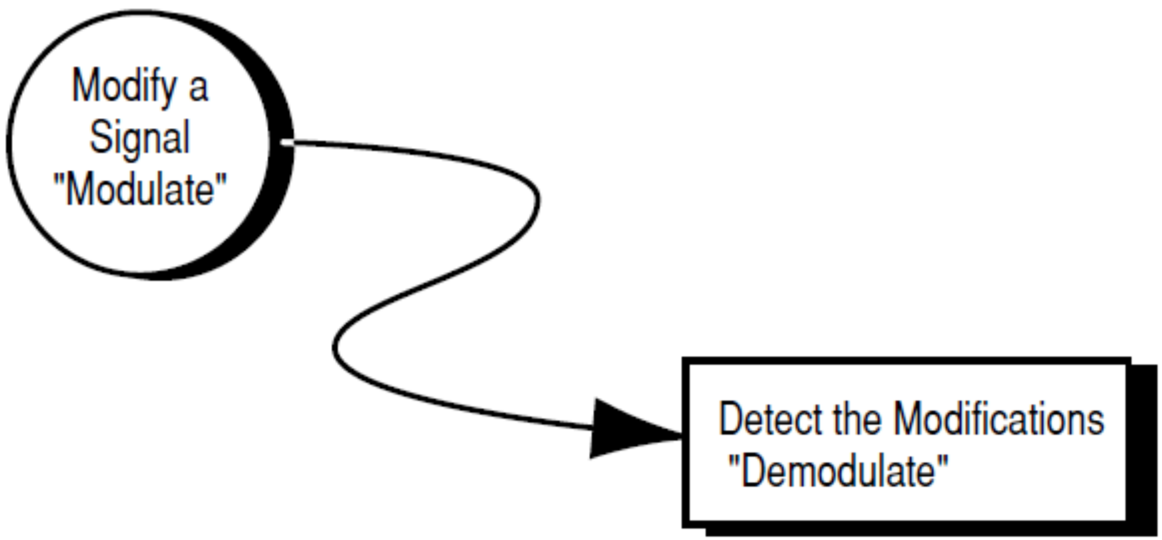
(b) A = 0.5, f = 1, ϕ = 0

(c) A = 1, f = 2, ϕ = 0

(d) A = 1, f = 1, ϕ = $\pi/4$

What is modulation ?

- Modulation = Adding information to a carrier signal
- The sine wave on which the characteristics of the information signal are modulated is called a carrier signal



Any reliably detectable change in signal characteristics can carry information

- Modulation is the general technique of shaping a signal to convey information.
- 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).
- **This is in contrast to analogue 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.**

Modulation

The carrier signal is usually just a simple, single-frequency sinusoid (varies in time like a sine wave).

The basic sine wave :$V(t) = Vo \sin(2 \pi f t + \phi)$

V(t) ->the voltage of the signal as a function of time.

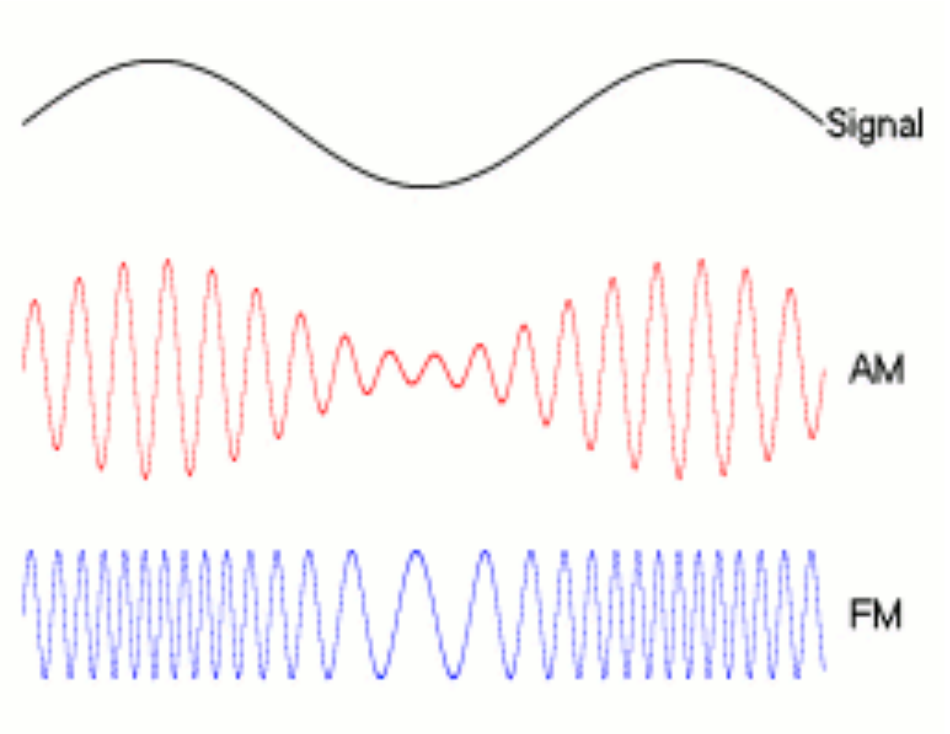
Vo-> the amplitude of the signal (represents the maximum value achieved each cycle)

f-> frequency of oscillation, the number of cycles per second

Φ –> phase of the signal, representing the starting point of the cycle.

To modulate the signal just means to systematically vary one of the three parameters of the signal: amplitude, frequency or phase.

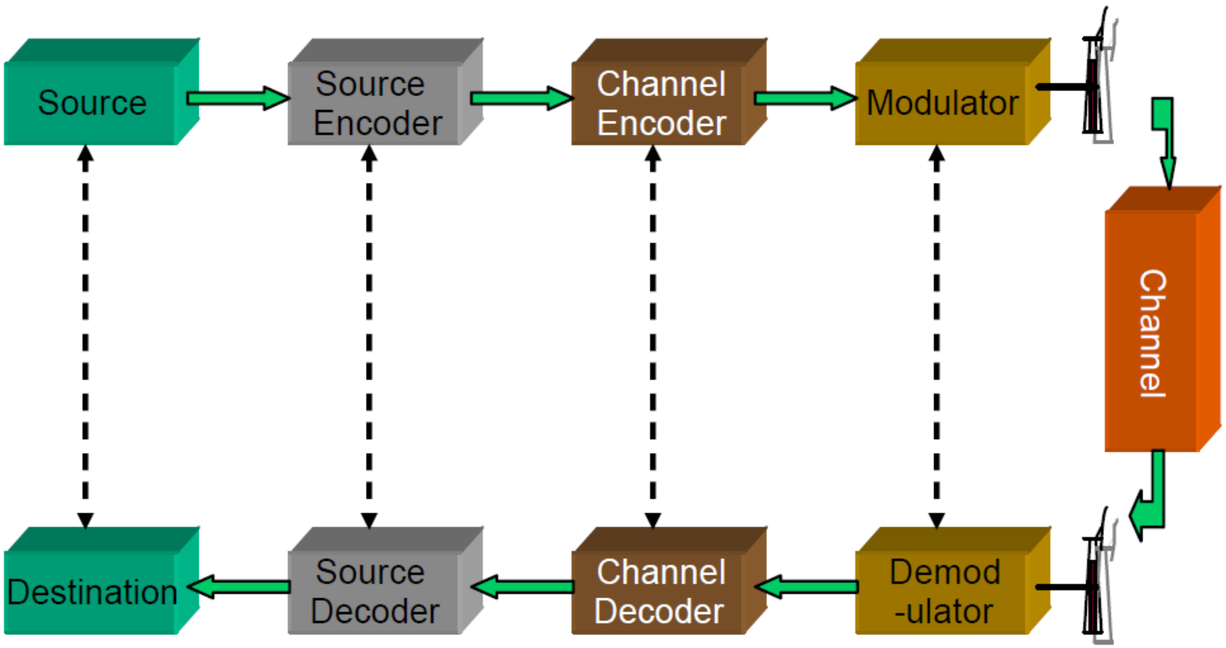
Analog modulation



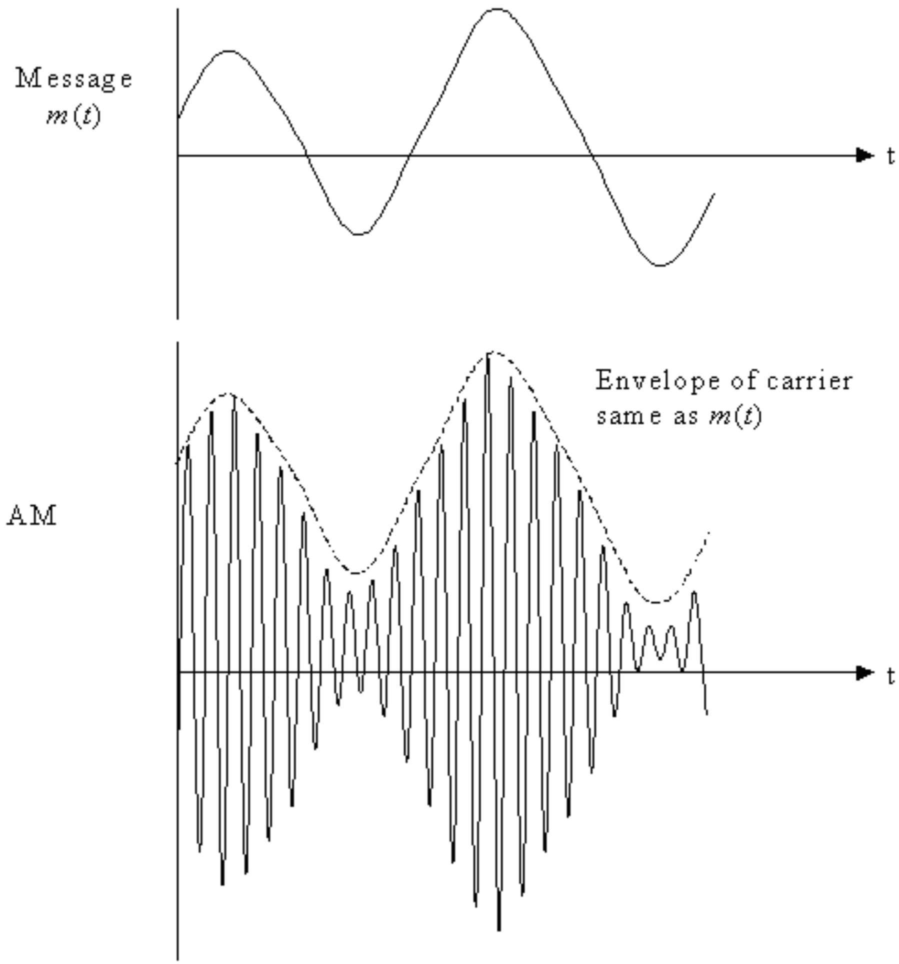
Modulation

Digital data can be transmitted via an analog carrier signal by modulating one or more of the carrier's three characteristics:

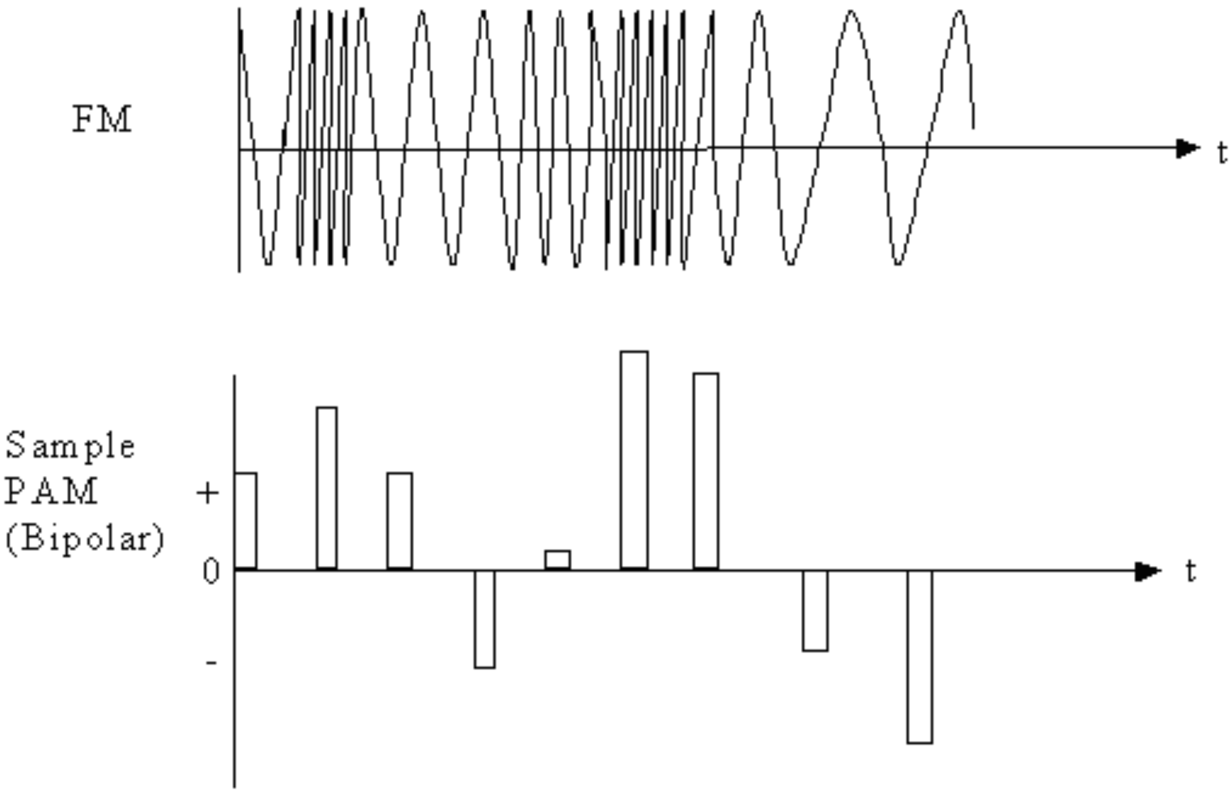
- amplitude
- frequency
- phase



Modulation Types AM, FM, PAM

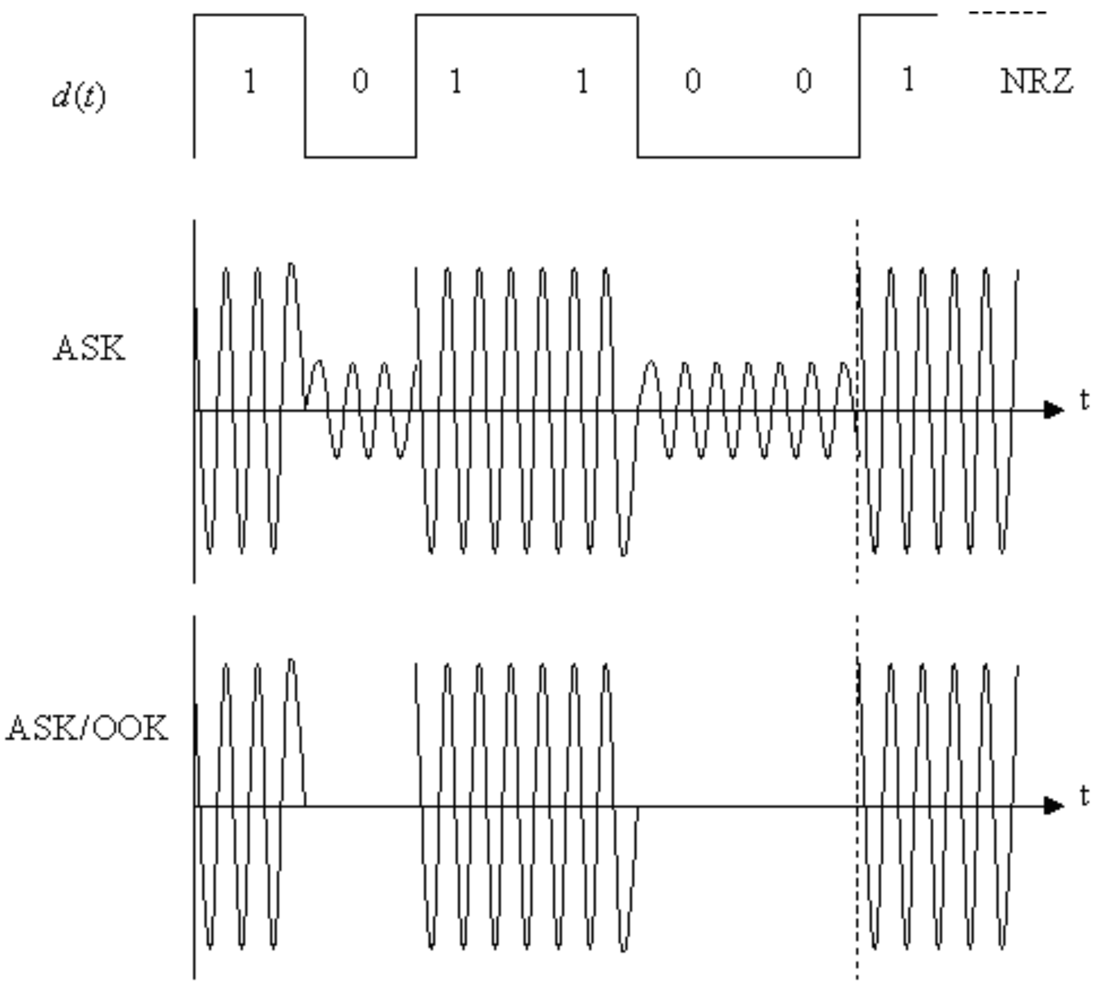


Modulation Types AM, FM, PAM

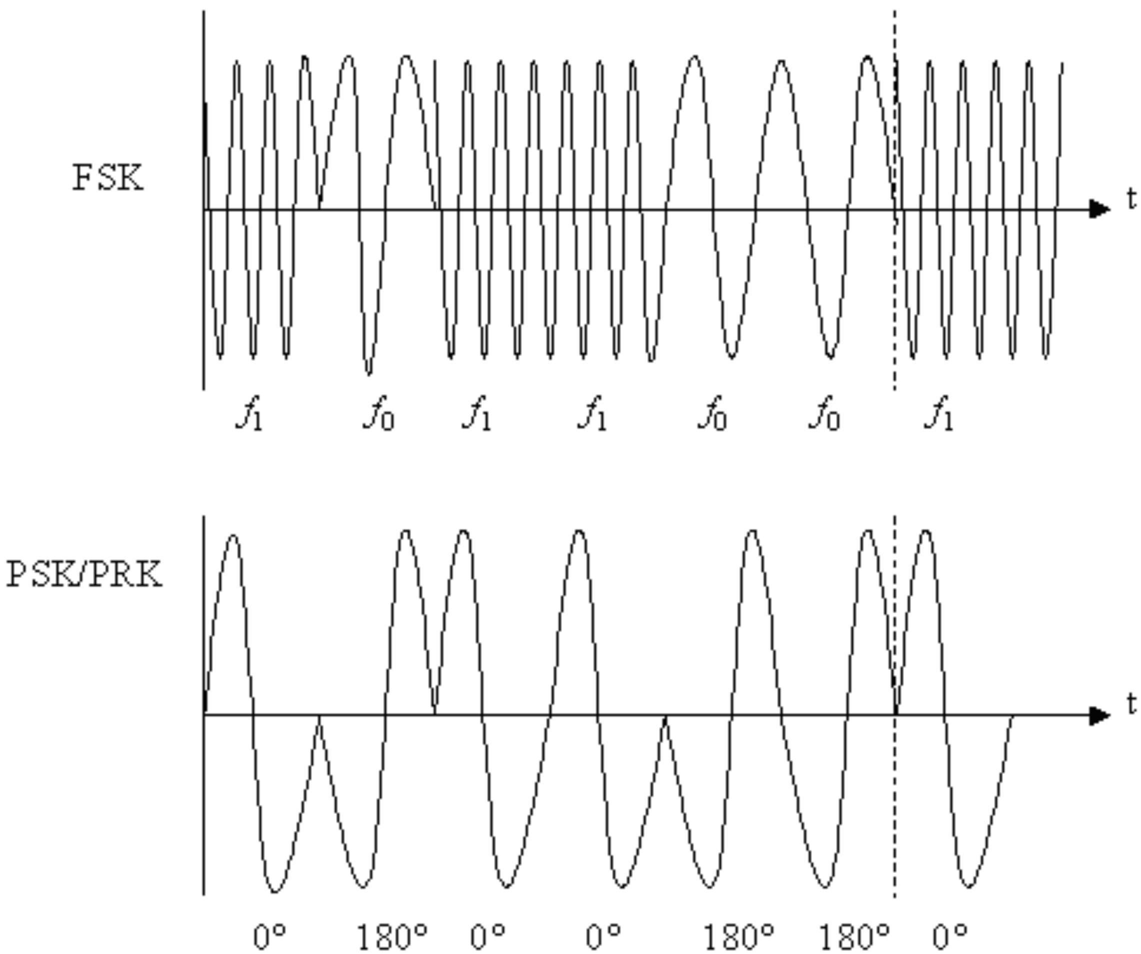


Pulse-Amplitude modulation

Modulation Types (Binary ASK, FSK, PSK)

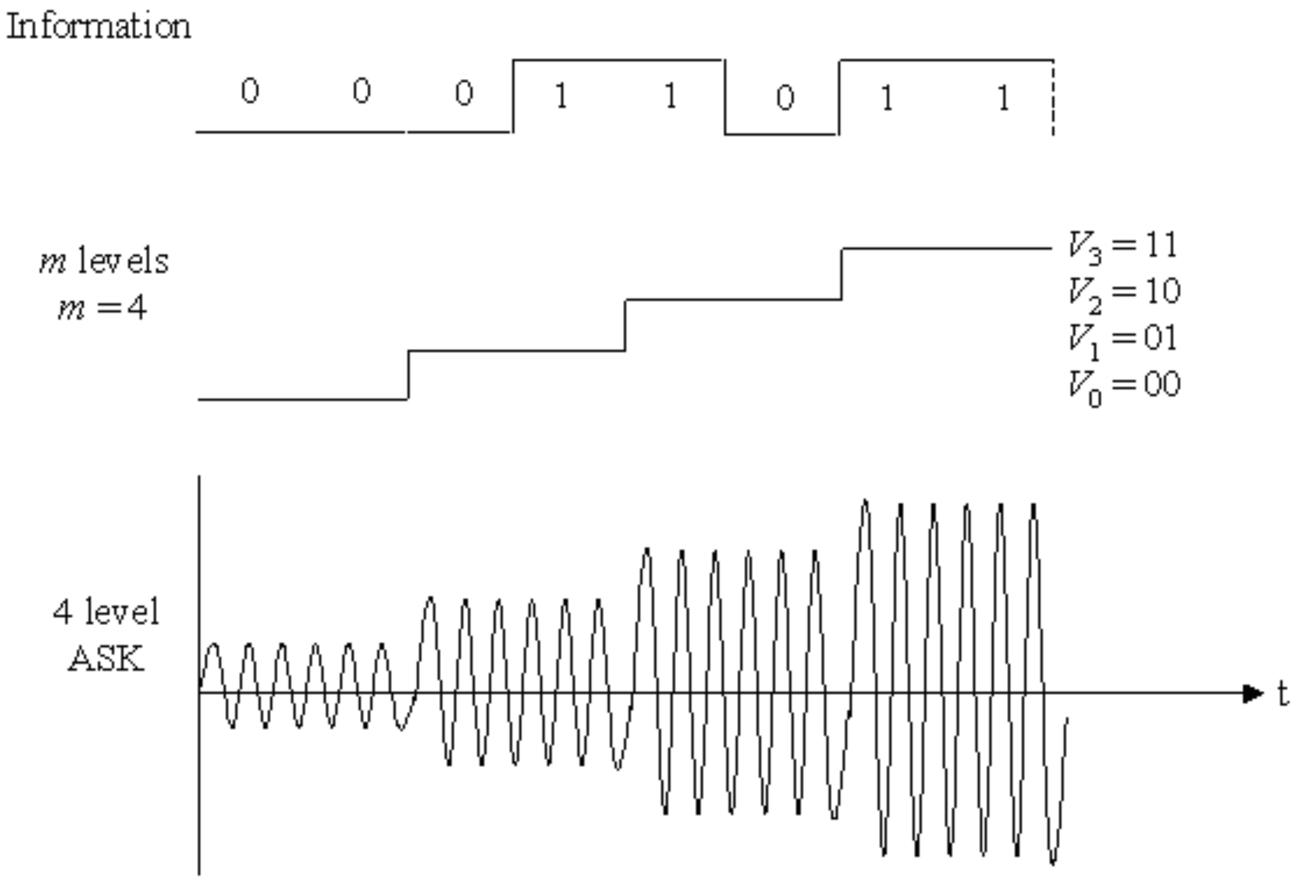


Modulation Types (Binary ASK, FSK, PSK) 2

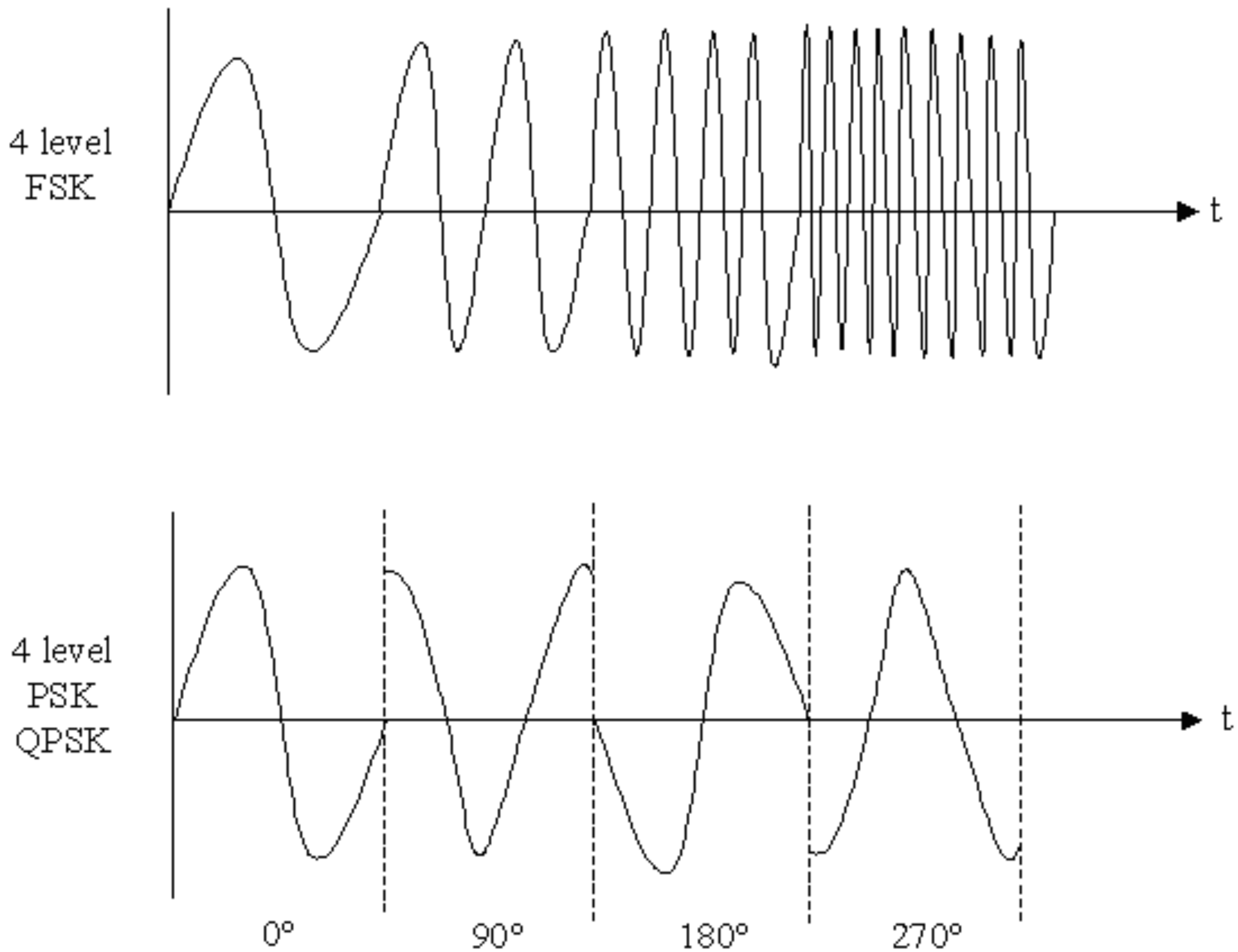


Phase Shift Keying (PSK)
Phase Reverse Keying (PRK)

Modulation Types – 4 Level ASK, FSK, PSK



Modulation Types – 4 Level ASK, FSK, PSK 2



Amplitude modulation

Amplitude modulation is the simplest of the three to understand. The transmitter just uses the information signal, Vm(t) to vary the amplitude of the carrier, Vco, to produce a modulated signal, VAM(t).

Here are the three signals 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)

Here, we see that the amplitude term has been replaced by the combination of the original amplitude plus the information signal.

Amplitude Modulation

The amount of modulation depends on the amplitude of the information signal.

This is usually expressed as a ratio of the maximum information signal to the amplitude of the carrier.

Modulation Index $m = MAX(V_m(t))/V_{co}$.

If the information signal is also a simple sine wave, the modulation index will be $m = V_{mo}/V_{co}$.

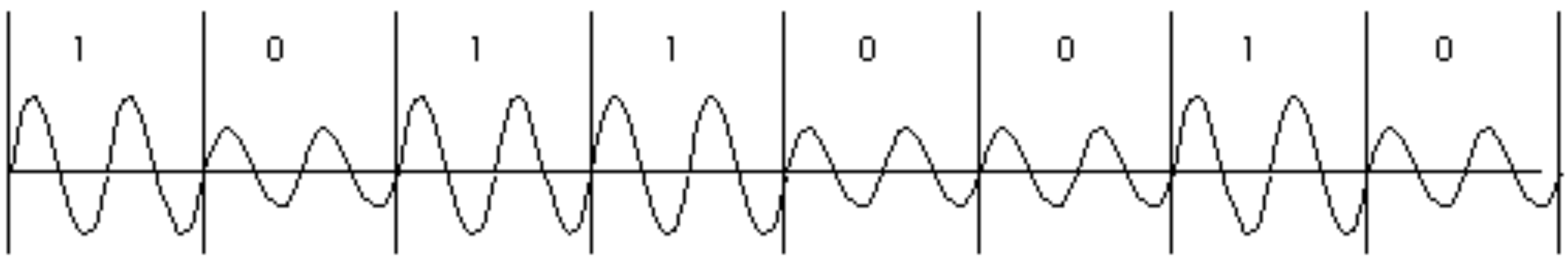
The interpretation of the modulation index, m, may be expressed as: The fraction (percentage if multiplied by 100) of the carrier amplitude that it varies by.

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%.

Modulation: Amplitude-Shift Keying (ASK)

ASK encodes digital data by modulating the carrier's amplitude between two or more levels. Suppose a signal with amplitude 1 represents a binary 0 and a signal with amplitude 2 represents a binary 1. AM is more sensitive to noise than other modulation techniques => AM is not widely used in data transmission

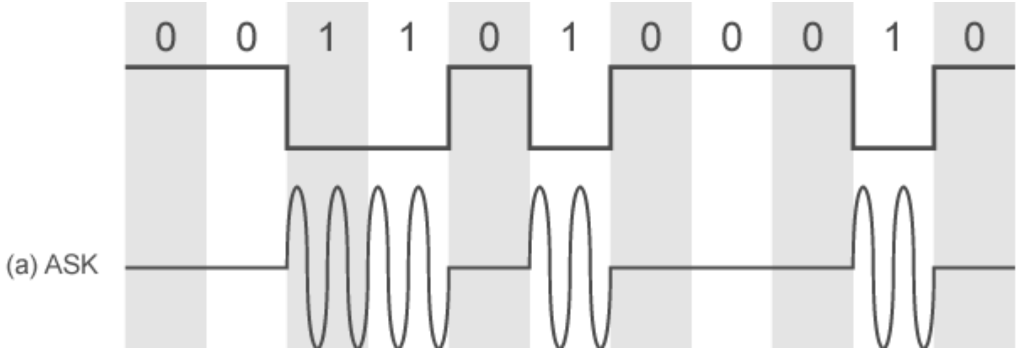
A period is the amount of time before a wave repeats itself.



Amplitude Shift Keying (ASK)

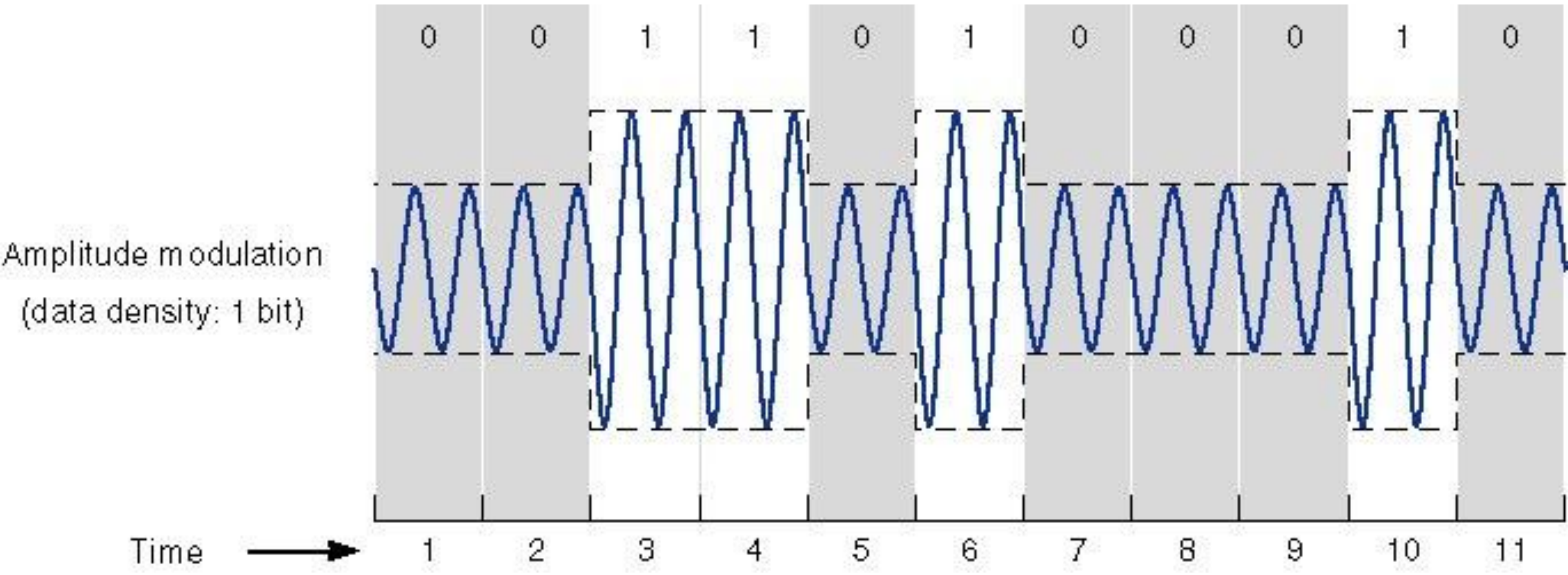
- In ASK, the two binary values are represented by to different amplitudes of the carrier frequency
- The resulting modulated signal for one bit time is

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



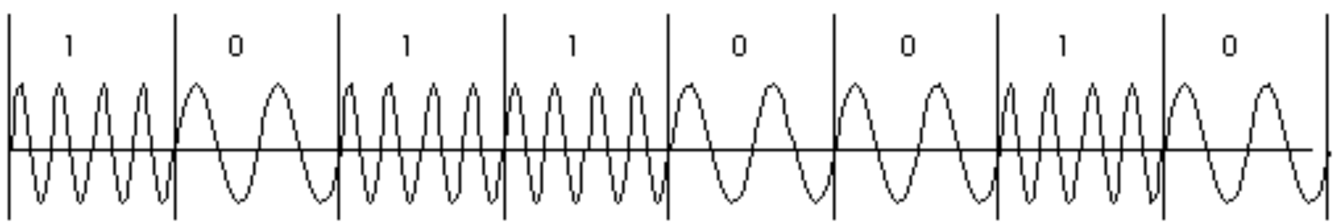
- Susceptible to noise
- Inefficient modulation technique
- used for
  - up to 1200bps on voice grade lines
  - very high speeds over optical fiber

Amplitude Modulation and ASK



Modulation: Frequency-Shift Keying (FSK)

Encodes digital data by modulating the carrier's frequency between two or more values. For example, a binary 0 would be one frequency (or group of frequencies) and a binary 1 would be some other frequency (or group of frequencies). *FSK* is less susceptible to corruption than ASK. Many modems use FSK to convert digital data to analogue signals.

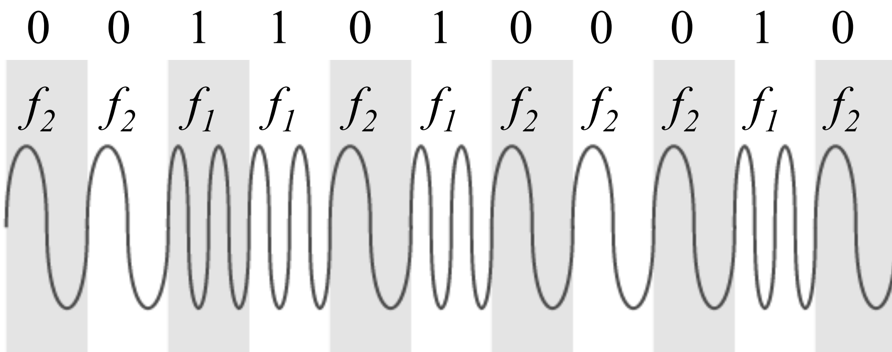


Binary Frequency Shift Keying (BFSK)

- The most common form of FSK is Binary FSK (BFSK)
- Two binary values represented by two different frequencies (f_1 and f_2)

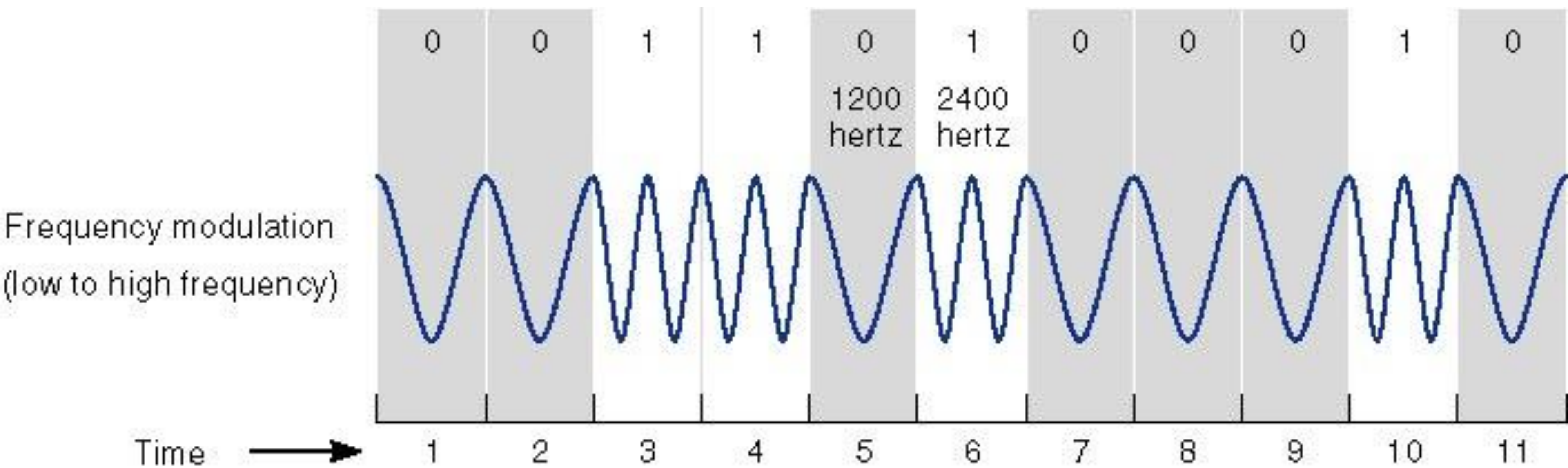
$$s(t) = \begin{cases} A\cos(2\pi f_1 t), & binary\ 1 \\ A\cos(2\pi f_2 t), & binary\ 0 \end{cases}$$

(b) BFSK



- less susceptible to noise than ASK
- used for
  - up to 1200bps on voice grade lines
  - high frequency radio (3 to 30MHz)
  - even higher frequency on LANs using coaxial cable

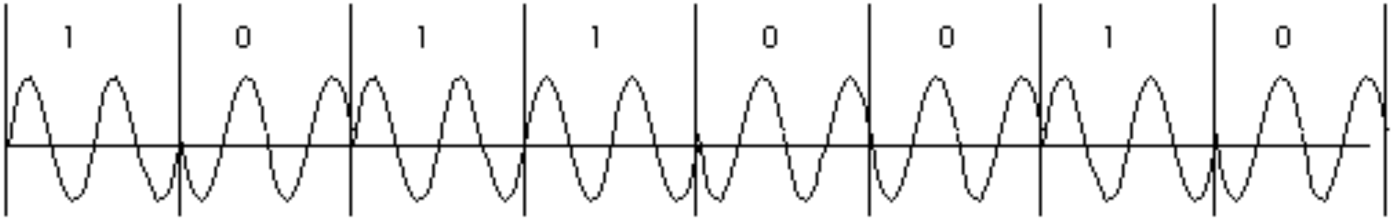
FSK



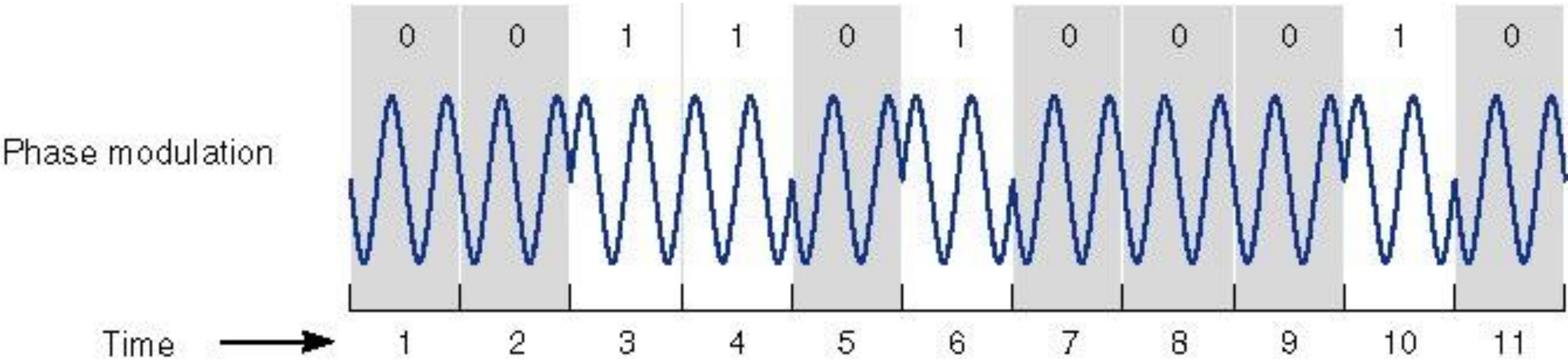
0
0
1
1
0
1
0
0
0
1
0
1200 hertz
2400 hertz
Frequency modulation
(low to high frequency)
Time
1
2
3
4
5
6
7
8
9
10
11

Modulation: Phase-Shift Keying (PSK)

Phase-shift keying encodes digital data by shifting the phase of the carrier. *PSK*-encoded data is highly resistant to corruption.



Phase Modulation and PSK



Demodulation

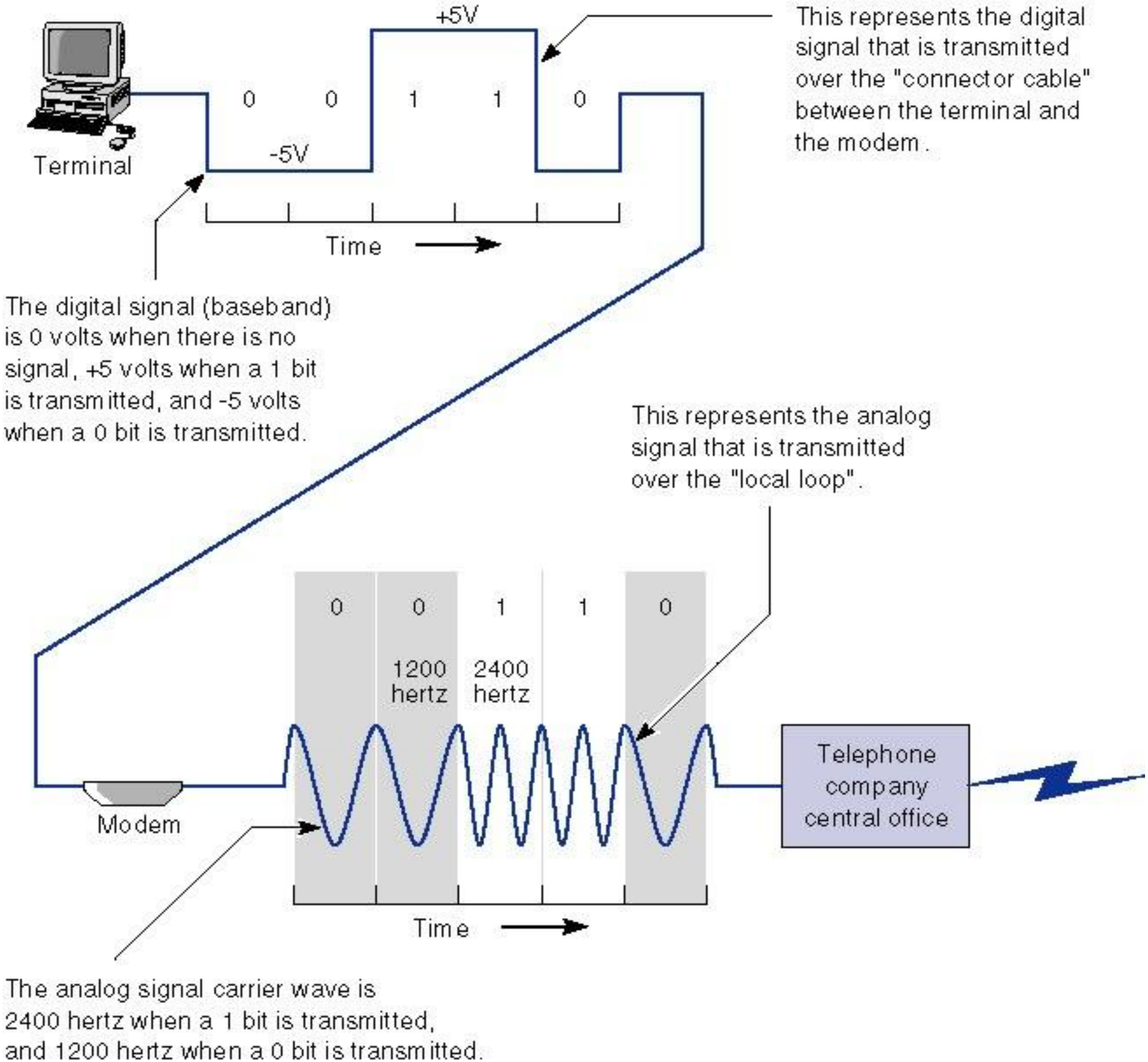
Demodulation is the process of extracting the digital information from the carrier.

ANALOG TRANSMISSION OF DIGITAL DATA

Analog Transmission occurs when the signal sent over the transmission media continuously varies from one state to another in a wave-like pattern.

e.g. telephone networks, originally built for human speech rather than data.

Advantage for long distance communications: much less attenuation for analog carrier than digital



+5V
This represents the digital signal that is transmitted over the "connector cable" between the terminal and the modem .
0 0 1 1 0
-5V
Terminal
Time
The digital signal (baseband) is 0 volts when there is no signal, +5 volts when a 1 bit is transmitted, and -5 volts when a 0 bit is transmitted.
This represents the analog signal that is transmitted over the "local loop".
0 0 1 1 0
1200 hertz
2400 hertz
Telephone company central office
Modem
Time
The analog signal carrier wave is 2400 hertz when a 1 bit is transmitted, and 1200 hertz when a 0 bit is transmitted.

Sending Multiple Bits Simultaneously

Each of the three modulation techniques can be refined to send more than one bit at a time. It is possible to send two bits on one wave by defining four different amplitudes.

This technique could be further refined to send three bits at the same time by defining 8 different amplitude levels or four bits by defining 16, etc. The same approach can be used for frequency and phase modulation.

Sending Multiple Bits Simultaneously