Ministry of Higher Education and Scientific Research

Al-Mustaqbal University

College Of Engineering & Technology

Computer Techniques Engineering Department

Computer Networks Fundamentals

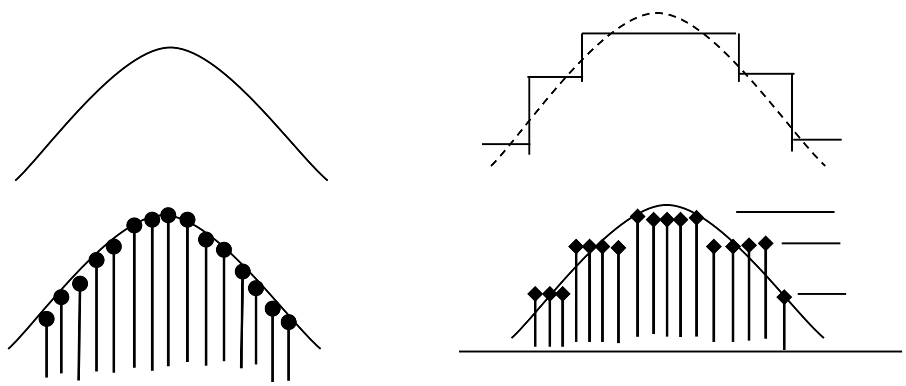
Lecture 11:

Encoding II

11.1- Analog-to-Digital Encoding

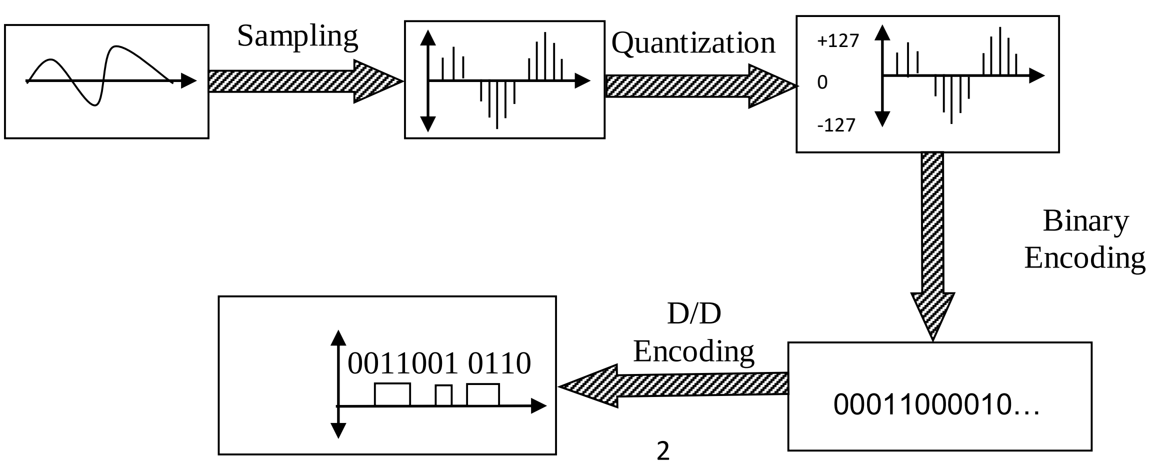
Analog information (images, speech, movies, etc.) are physically represented as analog signals. That is, a time-continuous and amplitude-continuous which need a potentially infinite number of values. Manipulating any analog information using a computer need to convert its analog representation which is not suitable to be stored in a digital device into a digital signal which more suitable to be manipulated by digital devices .

The figure below illustrates how analog signal enter the digital world by means of time discretization (Sampling) and amplitude discretization (Quantization).



Sampling **Quantization**

The entire process of A/D encoding illustrated in figure below:



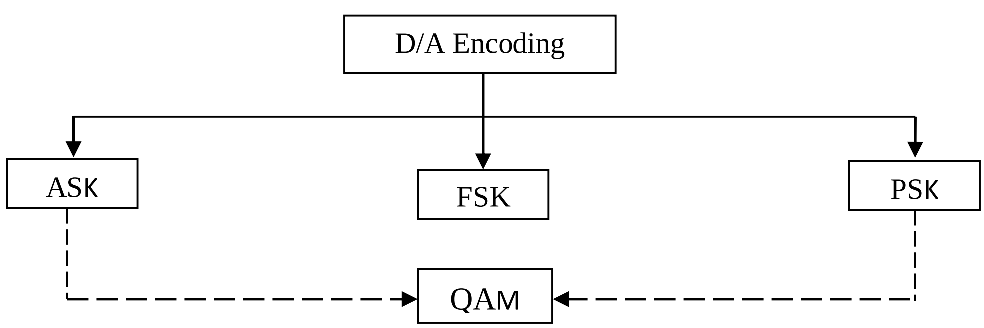
11.2- Digital-to-Analog Encoding

D/A encoding is the representation of digital information by an analog signal. Since digital communication still uses physical channels digital information must to be encoded on an analog signal that has been manipulated to look like two distinct values that correspond to binary 1 and binary 0.

Sine wave is the electrical signal mostly generated by the physical devices and most of our communication system rely on it. It can be defined by three characteristics; *Amplitude*, *Frequency*, and *Phase*. When we vary any one of these characteristics, we create another version of that wave. So, by changing one aspect of a simple electrical signal (making the binary 1, a binary 0 or the vice versa) back and forth, we can use it to represent digital data.

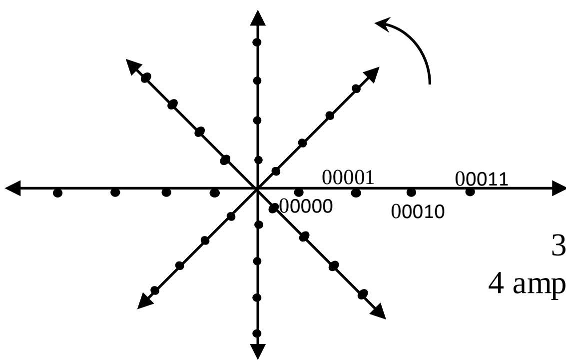
Any of the above three characteristics can be altered in this way giving us at least three mechanisms for encoding digital data in to analog signal ; *Amplitude Shift Keying* **(ASK)** , *Frequency Shift Keying* **(FSK)** , *and Phase Shift Keying* **(PSK)**. In addition to the *Quadrature Amplitude Modulation* (**QAM)** which is the most efficient of these options.

In analog transmission the sending device produces a *high-frequency* signal that acts as a basis for information signal. This base signal is called the *carrier signal* or carrier frequency. The receiving device is tuned to the frequency of the carrier signal. Digital information is then encoded onto the carrier signal by modifying one or more of its characteristics. This kind of modification is called **MODULATION** or **SHIFTKEYING**



Combining ASK and PSK gives an ***x*** variation in phase and ***y*** variations in amplitude. Producing x times ***y*** possible variations and corresponding number of bits per duration. A basic feature of QAM is that; *the number of amplitude shifts is fewer than the number of phase shift;* because amplitude changes are sensitive to noise.

Four amplitudes and eight phases (32-QAM), is the OSI recommendation.



32-QAM
4 amplitudes, 8 phases

- ***Bit-rate and Baud-rate***

Bit rate is the number of bits transmitted during one second. While *Baud rate (signaling rate)* refers to the number of signal units per second that are required to represent those bits, that is, the number of times per second the amplitude, frequency or phase of the transmission signal changes. Bit rate equal the baud rate times the number of bits represents by each signal unit. The baud rate equals the bit rate divided by the number of bits represented by each signal shift.

$$\text{Bit rate} = \ baud\ rate\ \times number\ of\ bit\ per\ signal$$

Example 4: Compute the bit rate for a 1000 baud 16-QAM signal

Solution:

A 16-QAM signal has 4 bits per signal unit since

$$\log_2 16 = \ 4$$

16-QAM means that there is 4 bits per signal

1000 × 4 = 4000 bps.

11.3- Analog-to-Analog Encoding

Analog-to-Analog encoding is the representation of analog information by an analog signal. Like *baseband modulation* (ASK, FSK, or PSK); *broadband modulation* is the operation of transmitting a signal using another signal called the *carrier* by changing one of the basic features of the carrier (amplitude, frequency, or phase); as shown in figure below: