វិទ្យាស្ថានបច្ចេកវិទ្យាកម្ពុជា
INSTITUTE OF TECHNOLOGY OF CAMBODIA

Department of Information and Communication Engineering

DIGITAL AND ANALOG TRANSMISSION

DC-L02

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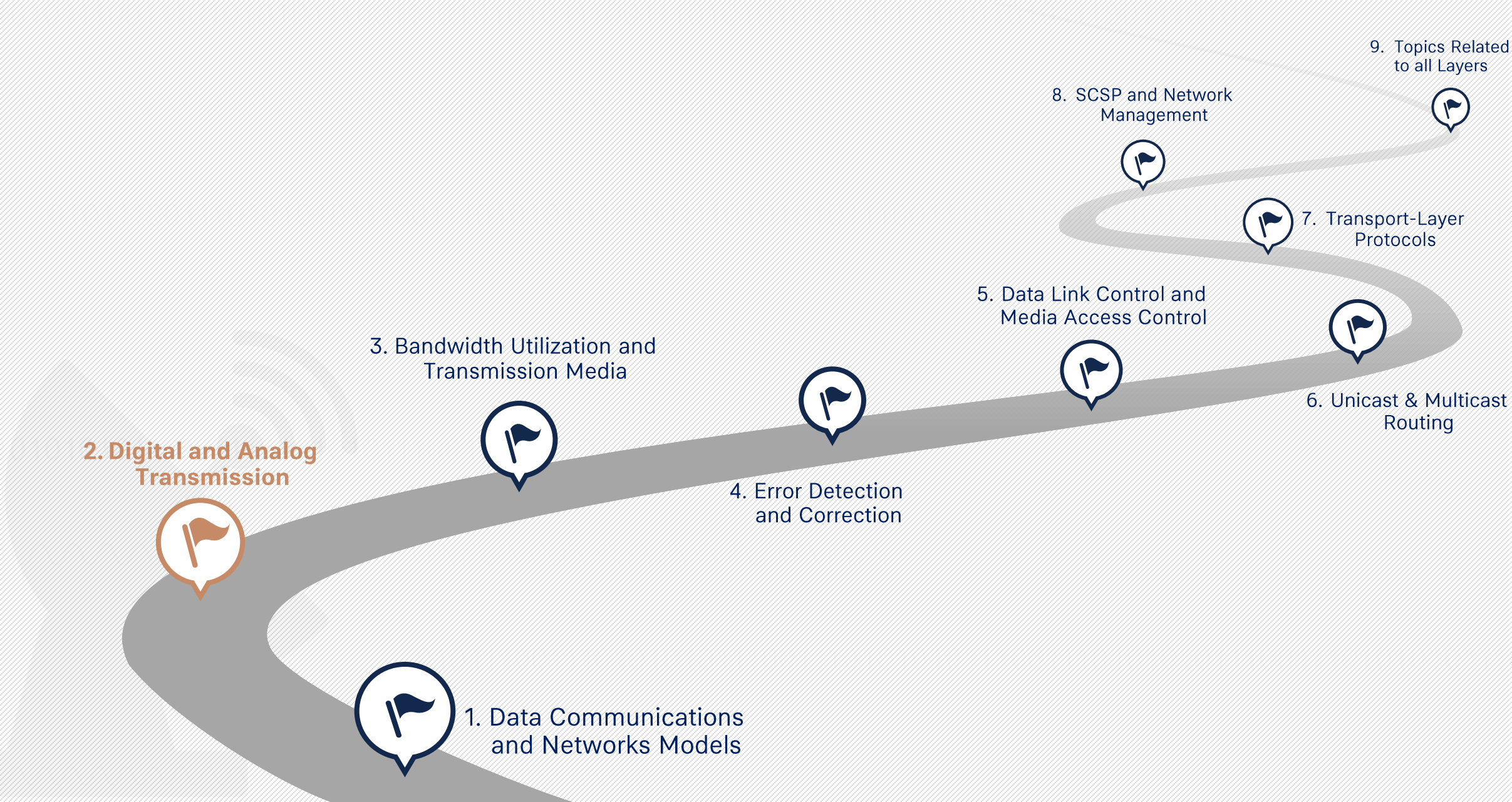
LEARNING MAP



ANALOG TRANSMISSION

PART-III

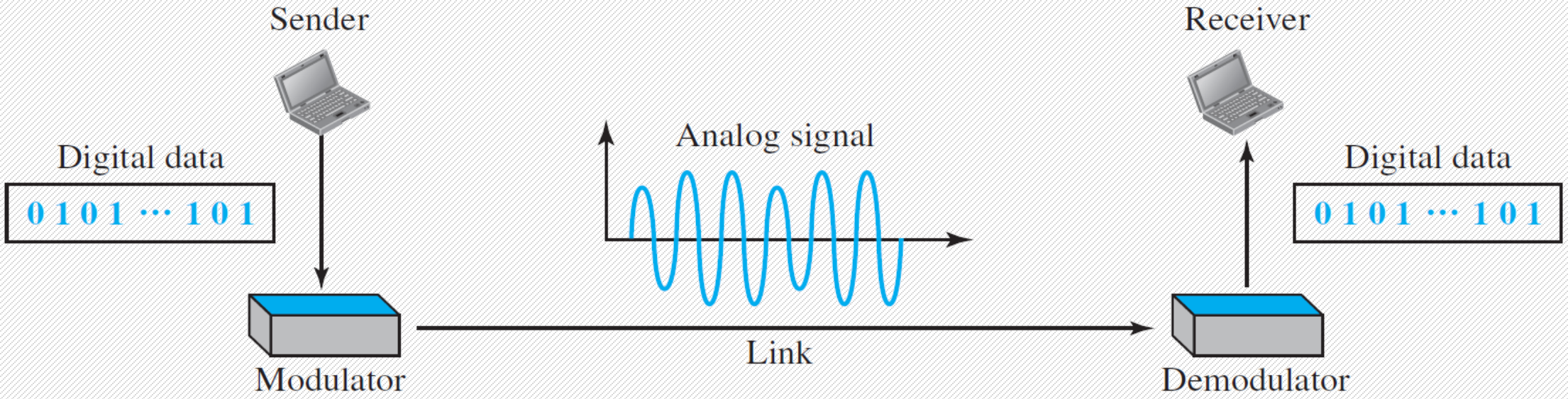
LEARNING OBJECTIVES

- Converting digital data to a Bandpass analog signal and a low-pass analog signal to a Bandpass analog signal.
- Digital-to-analog conversion; to shows how to change digital data to an analog signal when a band-pass channel is available: ASK, FSK, PSK, and QAM.
- Analog-to-analog conversion; to shows how an analog signal can change to a new analog signal with a smaller bandwidth: AM, FM, and PM.

LECTURE CONTENTS

1. DIGITAL-TO-ANALOG CONVERSION

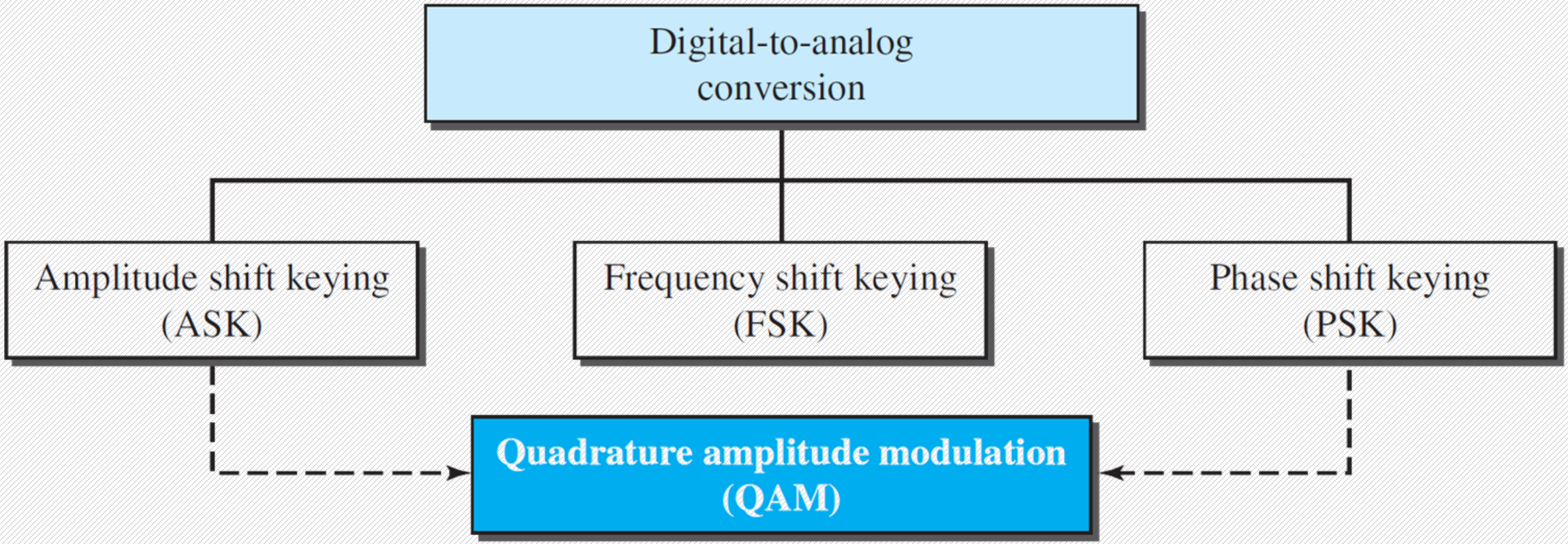
- Digital-to-analog conversion is the process of changing one of the characteristics of an analog signal based on the information in digital data.



Digital-to-analog conversion

1. DIGITAL-TO-ANALOG CONVERSION

- There are four mechanisms for modulating digital data into an analog signal: Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK), and Quadrature Amplitude Modulation (QAM).



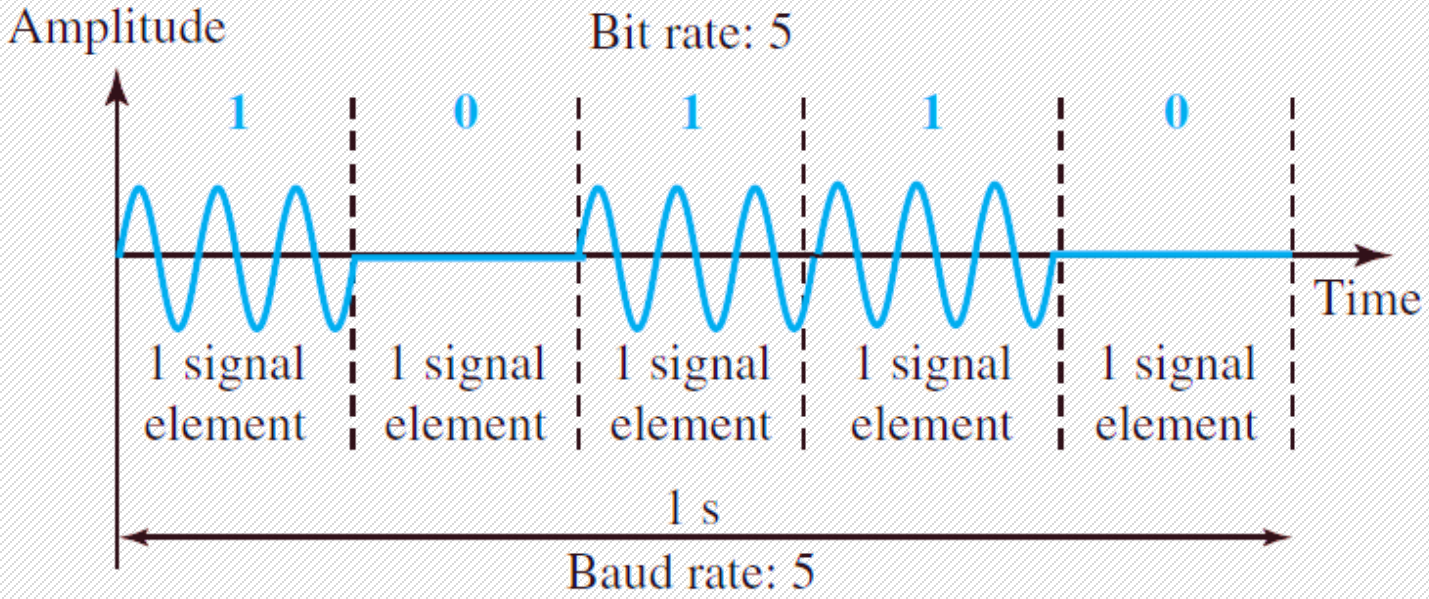
Types of digital-to-analog conversion

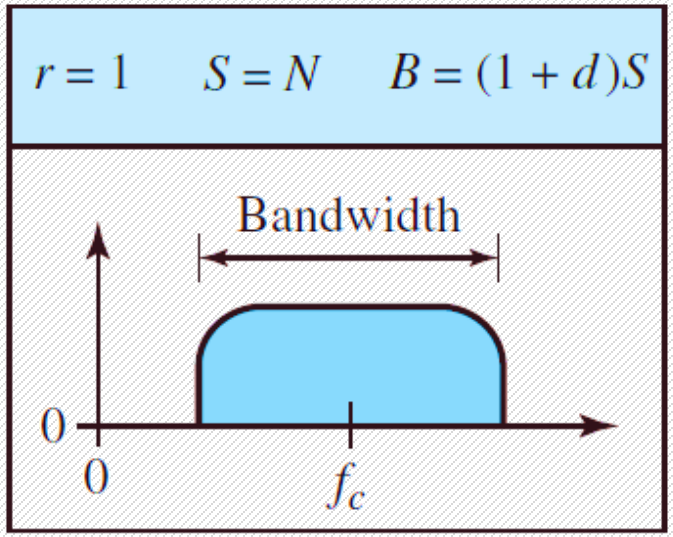
Aspects of Digital-to-Analog Conversion

- **Data Element** vs **Signal Element**: a data element as the smallest piece of information to be exchanged (bit); a signal element as the smallest unit of a signal that is constant.
- **Data Rate** vs **Signal Rate**: bit rate in the number of bits per second, baud rate in the number of signal elements per second. The relationship is: $S = N/r$ (baud).
- **Bandwidth**: the required bandwidth for analog transmission of digital data is proportional to the signal rate except for FSK, in which the difference between the carrier signals needs to be added.
- **Carrier Signal**: the sending device produces a high-frequency signal that acts as a base for the information signal, called carrier signal or carrier frequency. The receiving device is turned to the frequency of the carrier signal that it expects from the sender.

Amplitude Shift Keying

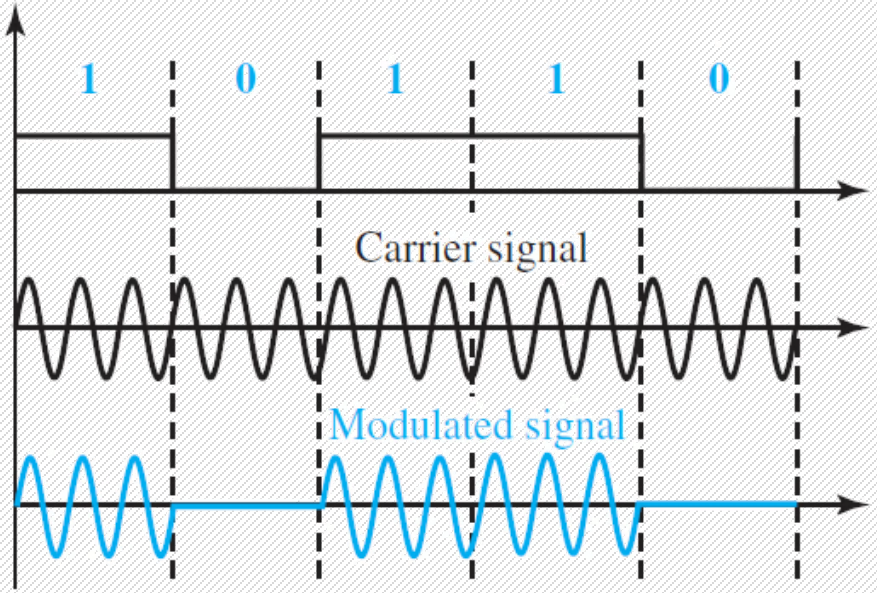
- **Binary ASK**: ASK normally implemented using only two levels with the peak amplitude of one signal level is 0; the other is the same as the amplitude of the carrier frequency.
- **Bandwidth for ASK**: carrier signal is only one simple sine wave, the process of modulation produces a nonperiodic composite signal. The bandwidth is proportional to the signal rate, where S is signal rate and B is the bandwidth: $B = (1 + d) \times S$.

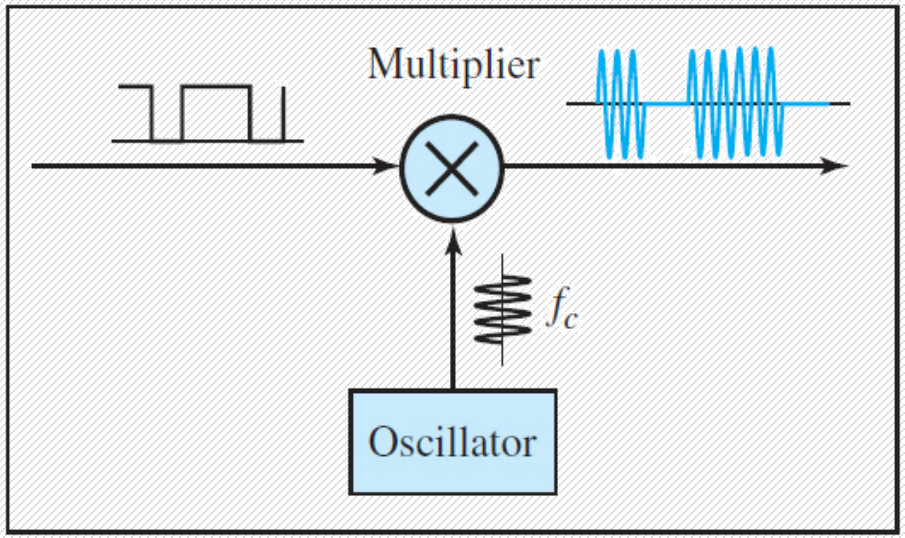




Amplitude Shift Keying

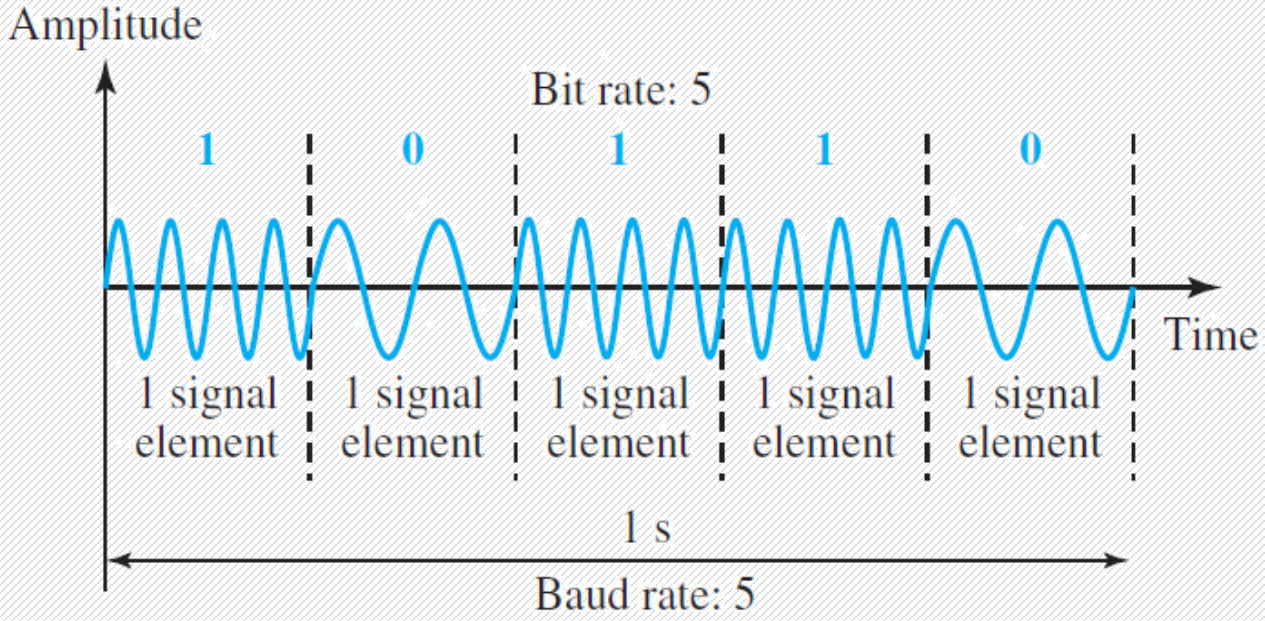
- **Implementation**: if the data are presented as a unipolar NRZ digital signal with a high voltage of 1V and a low voltage of 0V, the implementation can achieved by multiplying the NRZ digital signal by the carrier signal coming from an oscillator.

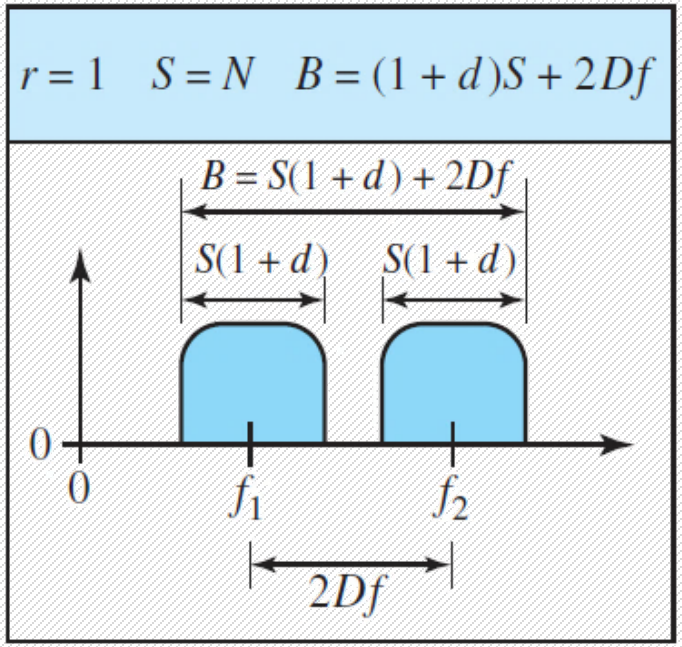




Frequency Shift Keying

- **Binary FSK**: is to consider two carrier frequencies $(f_1 \,\&\, f_2)$, the first carrier if the data element is 0; we use the second if the data element is 1. Normally the carrier frequencies are very high, and the different between them is very small $(2\Delta_f)$.
- **Bandwidth for BFSK**: if the difference between the two frequencies is $2\Delta_f$, then the required bandwidth is: $\boldsymbol{B = (1 + d) \times S \times 2\Delta_f}$

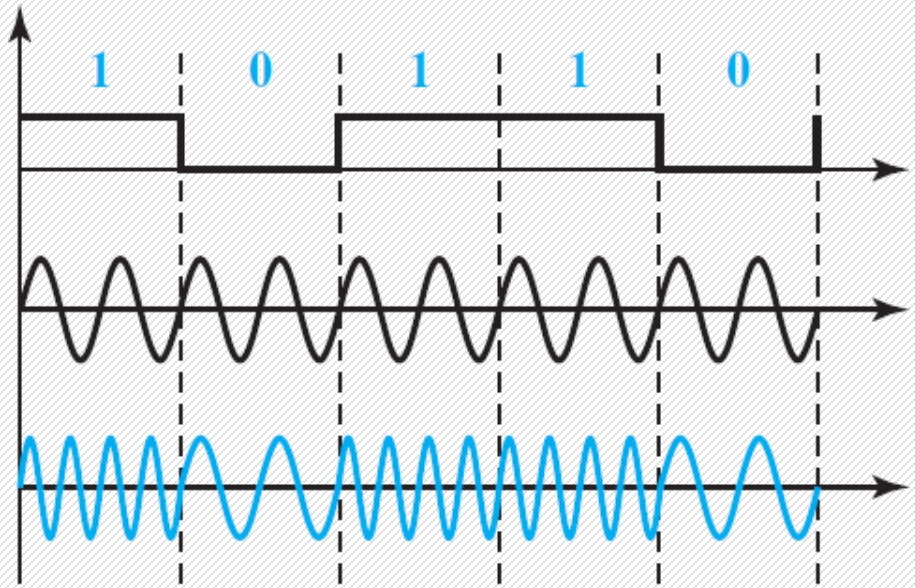


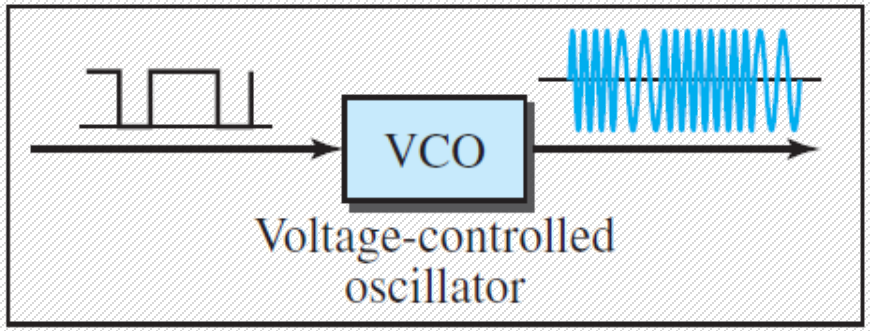


Frequency Shift Keying

- **Implementation**: there are two implementations of BFSK: noncoherent and coherent. Noncoherent implemented by treating BFSK as two ASK modulations and using two carrier frequencies. Coherent implemented by using on VCO.
- **Multilevel FSK**: for the proper operation of the modulator and demodulator, it can be shown that the minimum value of $2\Delta_f$ needs to be S, where the bandwidth is:

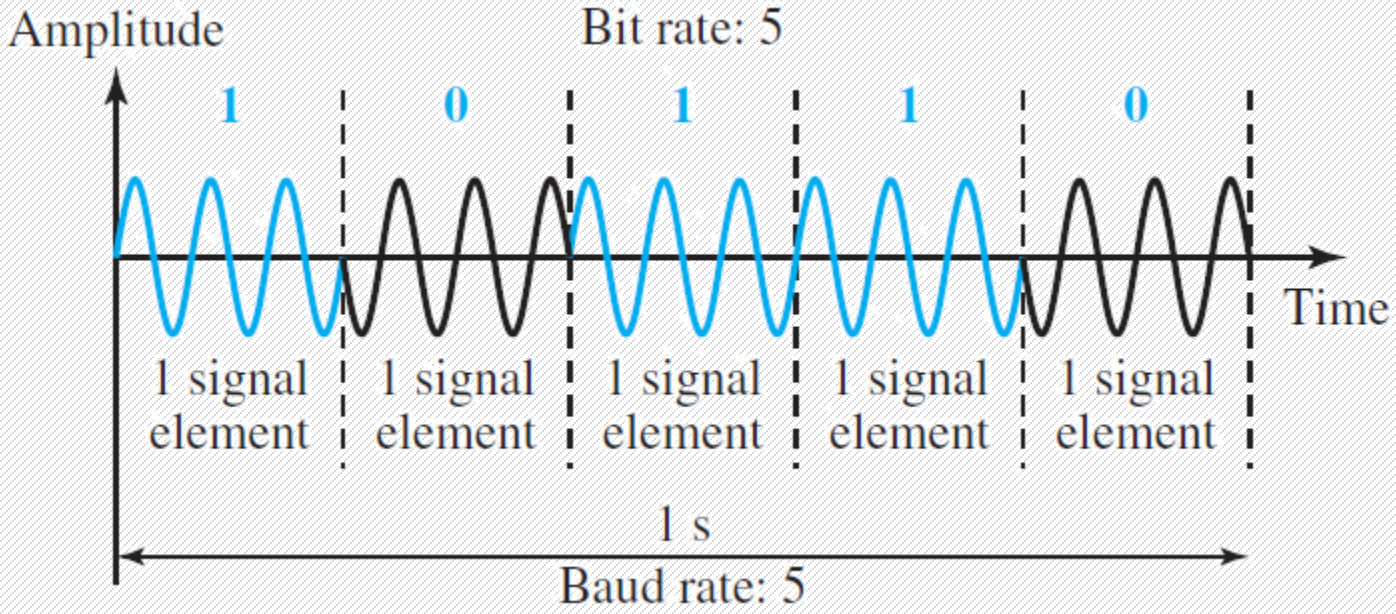
$$\boldsymbol{B = (1 + d) \times S + (L - 1)2\Delta_f \;\rightarrow\; B = L \times S}$$

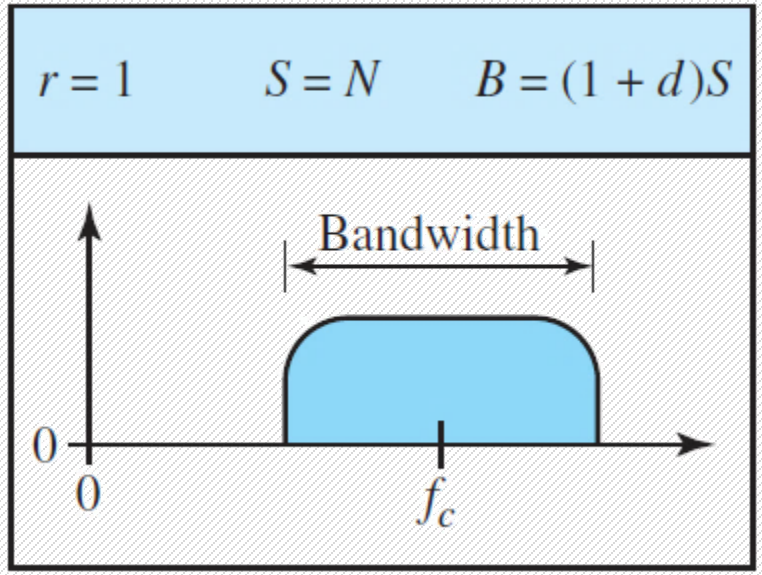




Phase Shift Keying

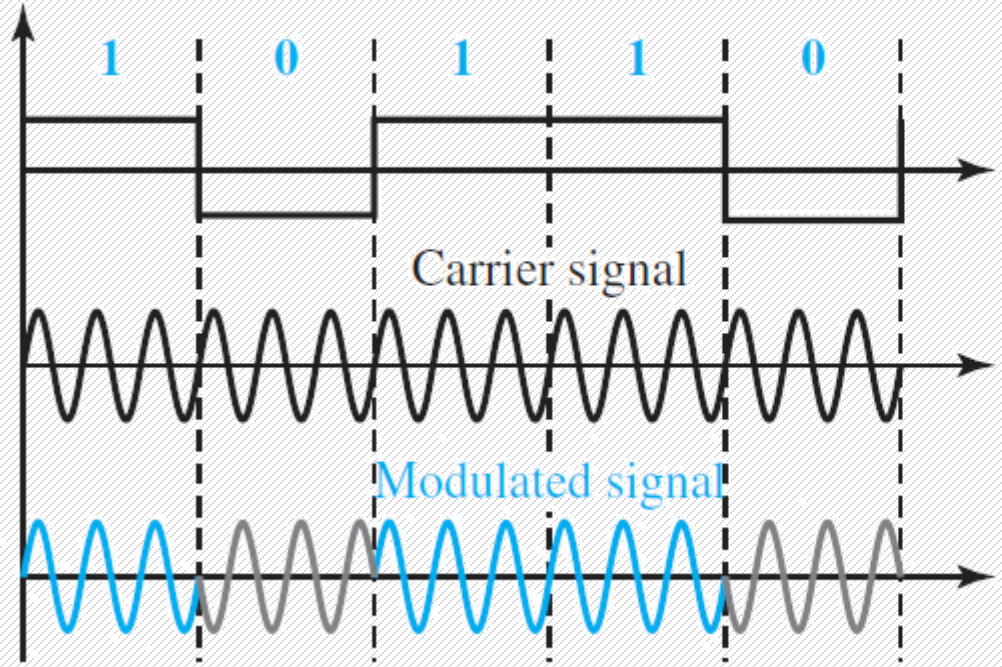
- In PSK, the phase of the carrier is varied to represent two or more different signal element. Both peak amplitude and frequency remain constant as the phase change.
- **Binary PSK**: only two signal elements, one with a phase of 0°, and the other with a phase of 180°. Noise can change the amplitude easier than it can change the phase.

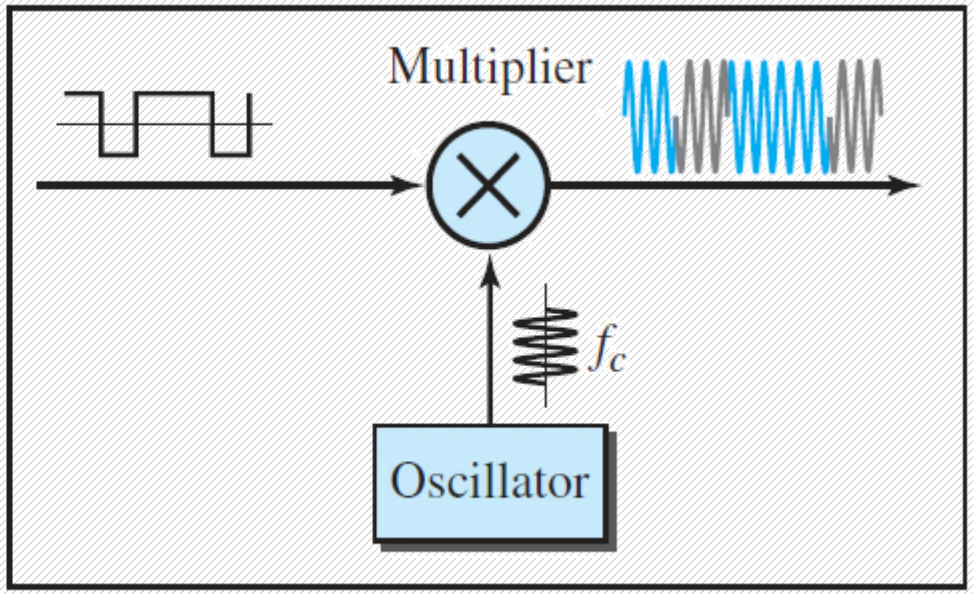




Phase Shift Keying

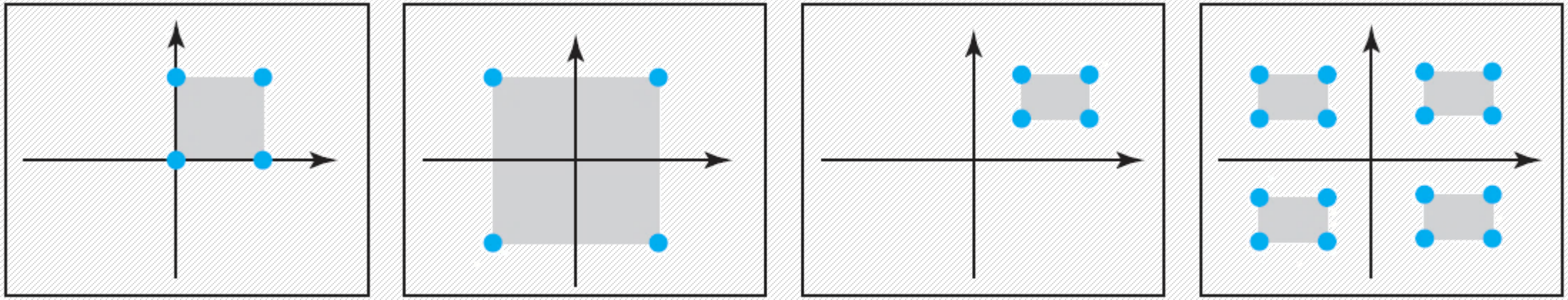
- **Implementation**: the signal element with phase 180° can be seen as the complement of the signal element with phase 0°. The signal is multiplied by the carrier frequency; the 1 bit (positive voltage) is represented by a phase starting at 0°; the 0 bit (negative voltage) is represented by a phase starting at 180°.





Quadrature Amplitude Modulation

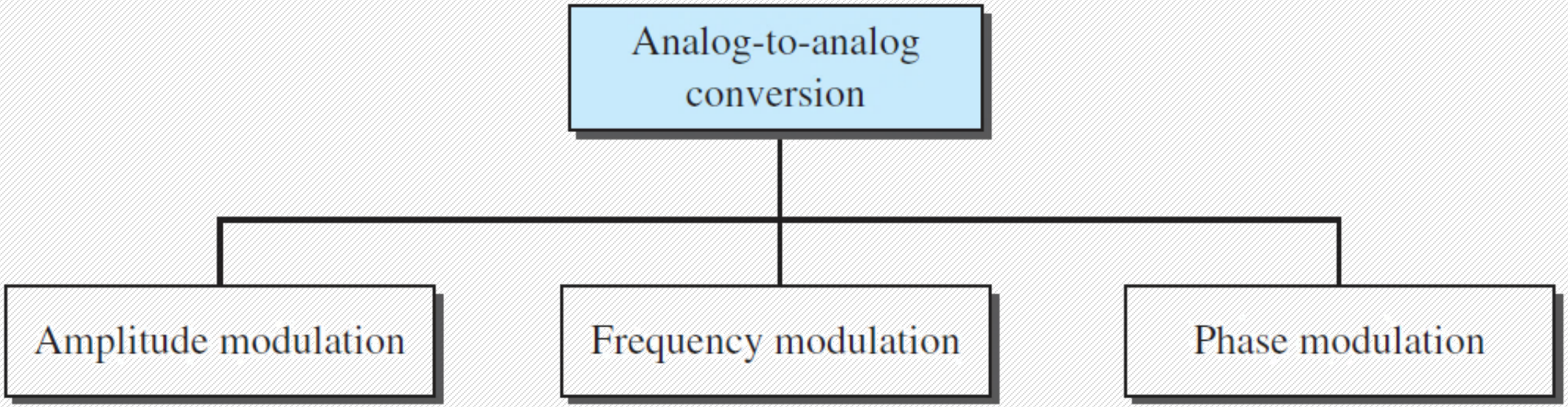
- QAM is a combination of ASK and PSK. The idea of using two carriers, one in-phase and the other quadrature, with different amplitude levels for each carrier.
- **Bandwidth for QAM**: the minimum bandwidth required for QAM transmission is the same as that required for ASK and PSK transmission.



a. 4-QAM b. 4-QAM c. 4-QAM d. 16-QAM

2. ANALOG-TO-ANALOG CONVERSION

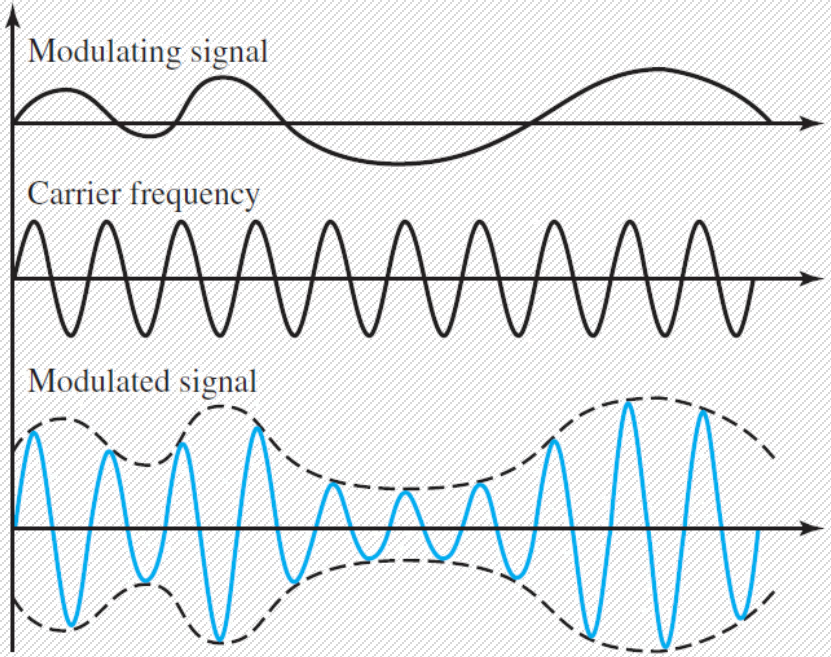
- Analog-to-analog conversion is the representation of analog information by an analog signal. It is needed if the medium is bandpass channel.
- Analog-to-analog conversion can be accomplished in three ways: Amplitude modulation (AM), frequency modulation (FM), and phase modulation (PM).

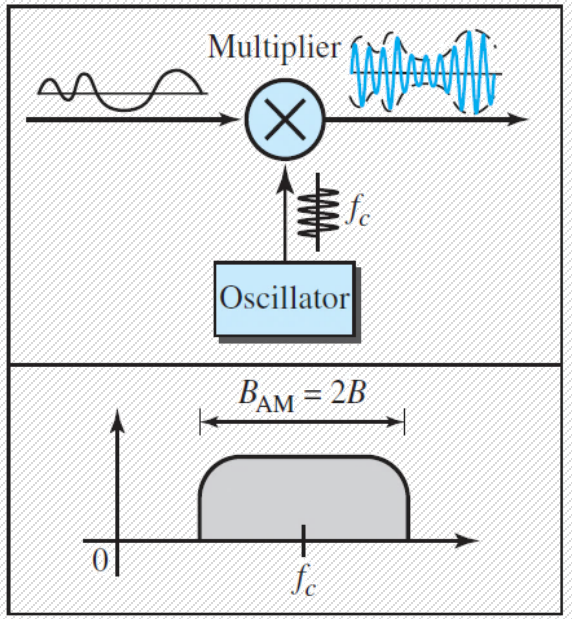


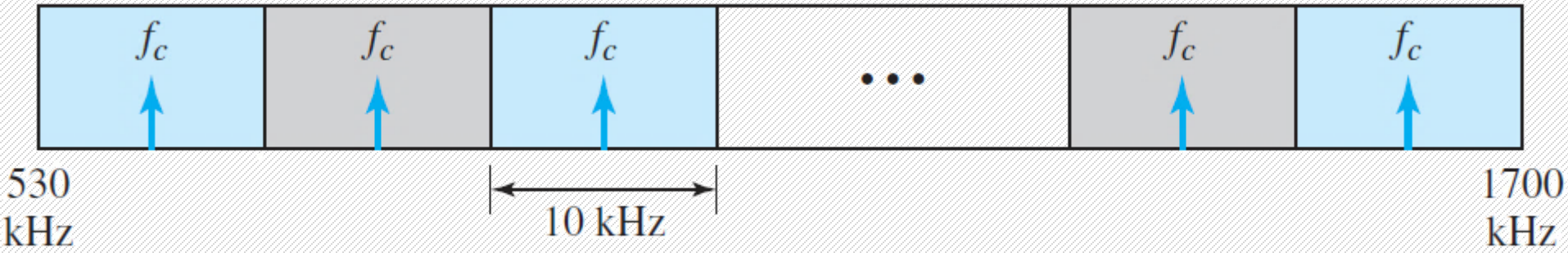
Types of analog-to-analog modulation

Amplitude Modulation (AM)

- In AM transmission, the carrier signal is modulated so that its amplitude varies with the changing amplitudes of the modulating signa.
- The total bandwidth required for AM can be determined from the bandwidth of the audio signal: $B_{AM} = 2B$.



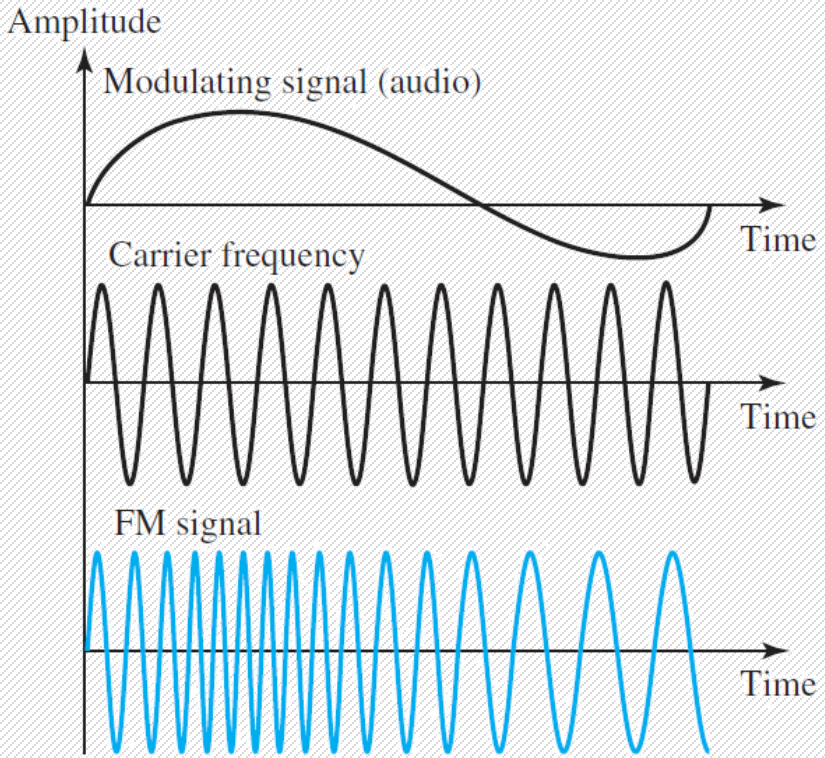


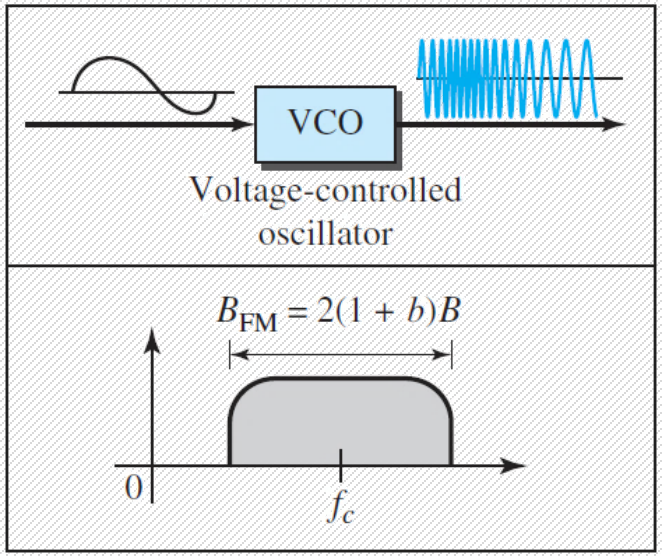


Frequency Modulation (FM)

- In FM transmission, frequency of the carrier signal is modulated to follow the changing voltage level of the modulating signal.
- FM bandwidth: the total bandwidth required for FM can be determined from the bandwidth of the audio signal:

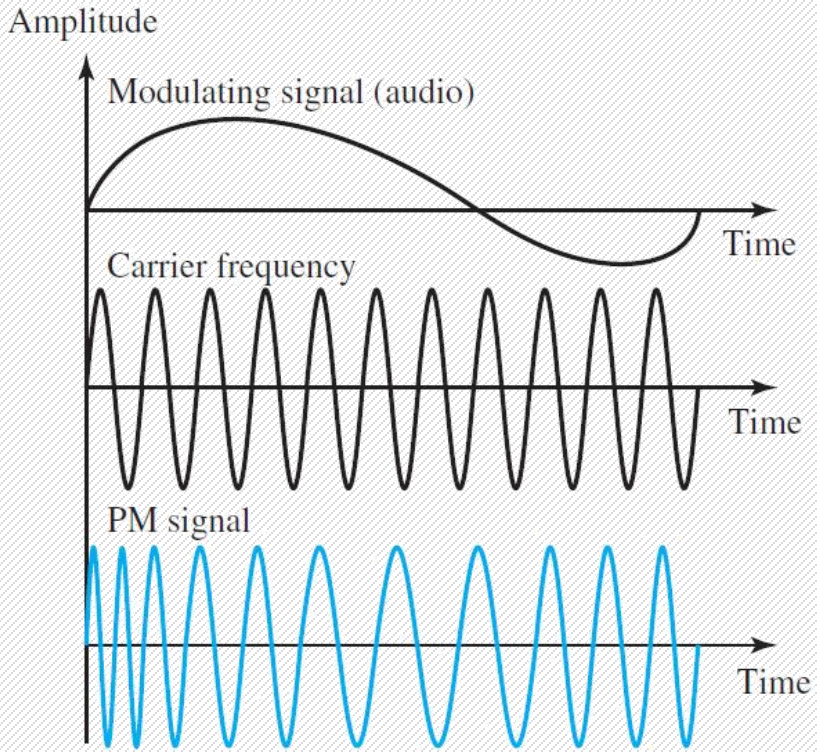
$$B_{FM} = 2(1 \times \beta)B$$

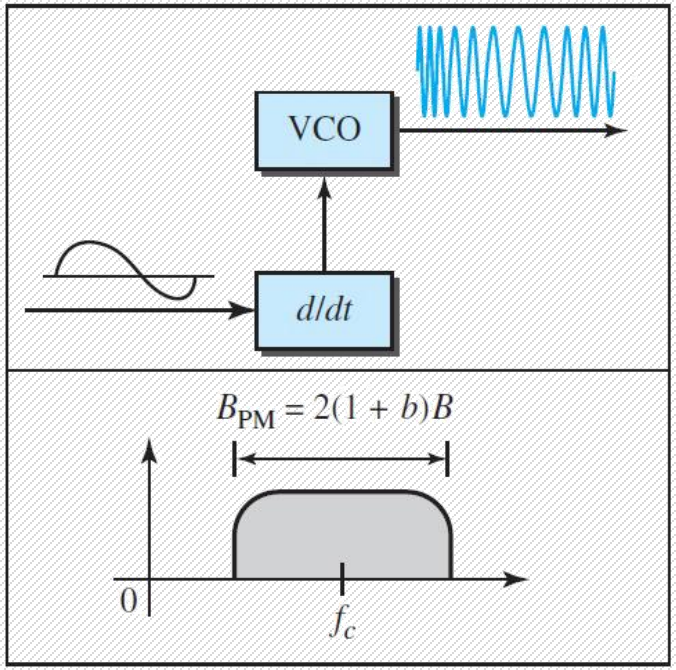




Phase Modulation (PM)

- In PM transmission, the phase of the carrier signal is modulated to follow the changing voltage level of the modulating signal.
- The total bandwidth required for PM can be determined from the bandwidth and maximum amplitude of the modulating signal: $B_{PM} = 2(1 + \beta)B$





3. SUMMARY

Digital-to-Analog Conversion

The process of changing one of the characteristics of an analog signal based on the information in the digital data, accomplished in several ways: **ASK**, **FSK**, **PSK**, and **QAM**.

Analog-to-Analog Conversion

The representation of analog information by an analog signal. Conversion is needed if the medium is bandpass in nature or if only a bandpass bandwidth is available to us, it can be accomplished in three ways: **AM**, **FM**, and **PM**.

4. HOMEWORK

1. Define digital-to-analog conversion and analog-to-analog conversion.
2. Which of the four digital-to-analog conversion techniques (ASK, FSK, PSK, or QAM) is the most susceptible to noise? Defend your answer.
3. Which characteristics of an analog signal are changed to represent the lowpass analog signal in each of the following analog-to-analog conversions?

   a. AM b. FM c. PM

4. Find the bandwidth of the following situations if we need to modulate a 5-KHz voice.
5. What is the required bandwidth for the following case if we need to send 4000 bps? Let d = 1.

   a. ASK b. FSK with $2\Delta_f = 4KHz$ c. QPSK d. 16-QAM

THANK YOU!

ANY QUESTION?