Encoding Digital Data with Analog Signals

Computer Networks(CS31204)

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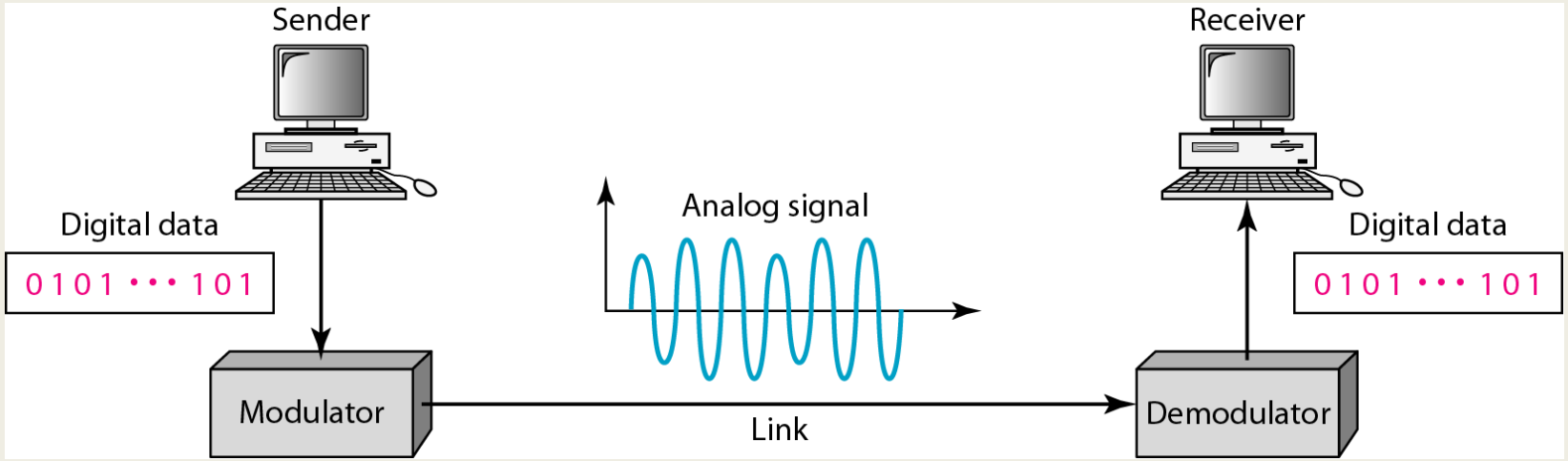
Digital to Analog Conversion

- 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 data needs to be carried on an analog signal.
- A carrier signal (frequency f_c) performs the function of transporting the digital data in an analog waveform.
- The analog carrier signal is manipulated to uniquely identify the digital data being carried.



Source: B. A. Forouzan, " Data Communications and Networking ," *McGraw-Hill Forouzan Networking Series*,5E.

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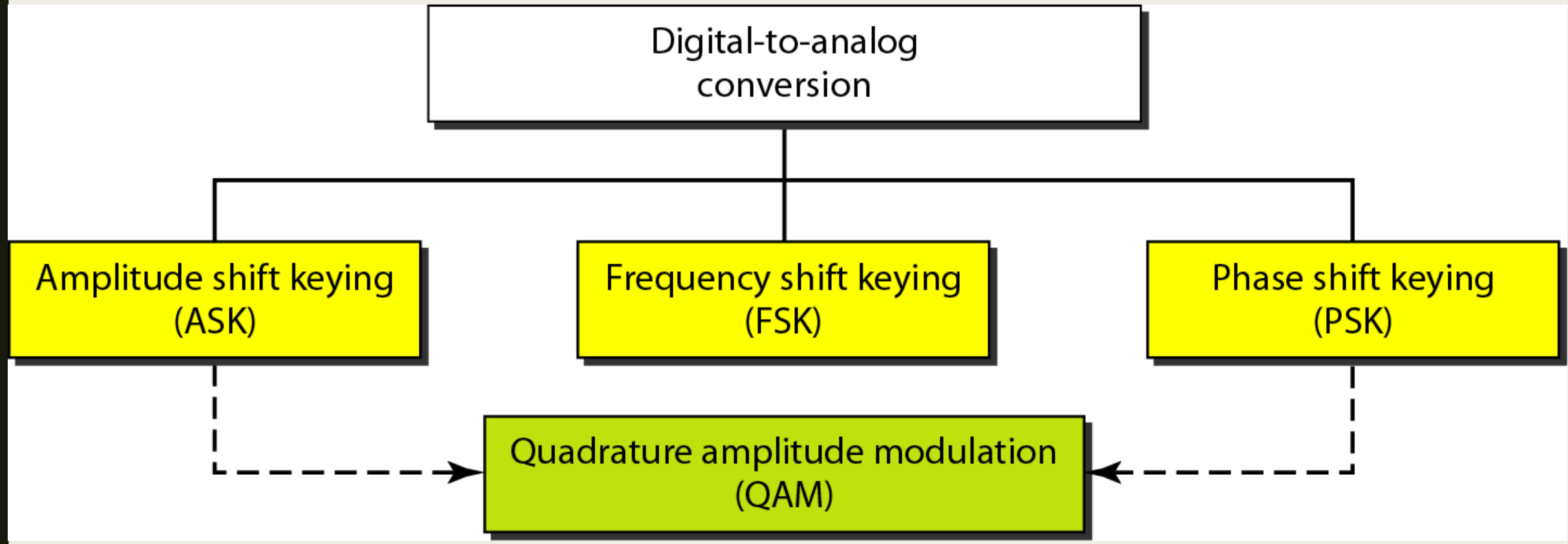
- Bit rate, N, is the number of bits per second (bps).
- Baud rate is the number of signal elements per second (bauds).
- In the analog transmission of digital data, the signal or baud rate is less than or equal to the bit rate.

$$S = N \times 1/r \text{ bauds}$$

Where r is the number of data bits per signal element.

Types



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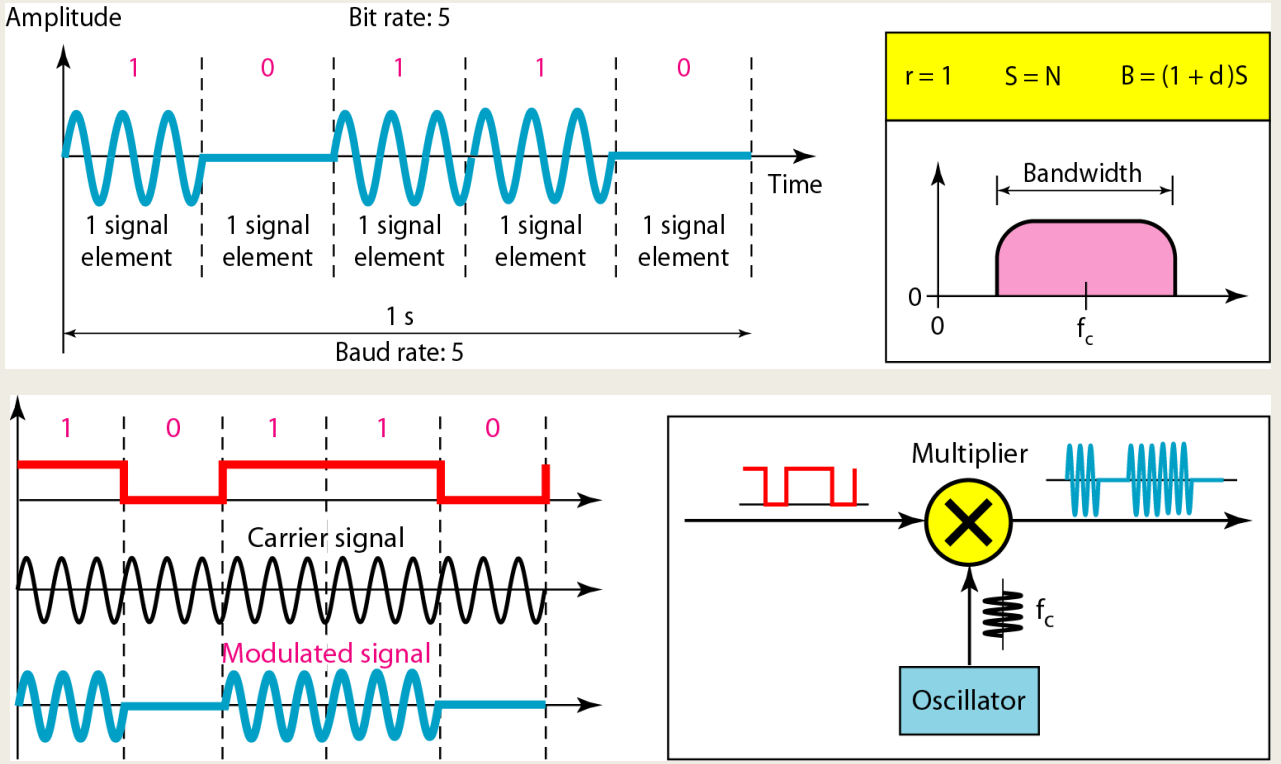
Amplitude Shift Keying

- ASK is implemented by changing the amplitude of a carrier signal to reflect amplitude levels in the digital signal.
- For example: a digital “1” could not affect the signal, whereas a digital “0” would, by making it zero.
- The line encoding will determine the values of the analog waveform to reflect the digital data being carried.

Binary Amplitude Shift Keying

- Normally implemented using only two levels.
- Referred to as binary amplitude shift keying or *on-off keying* (OOK).
- The peak amplitude of one signal level is 0; the other is the same as the amplitude of the carrier frequency.



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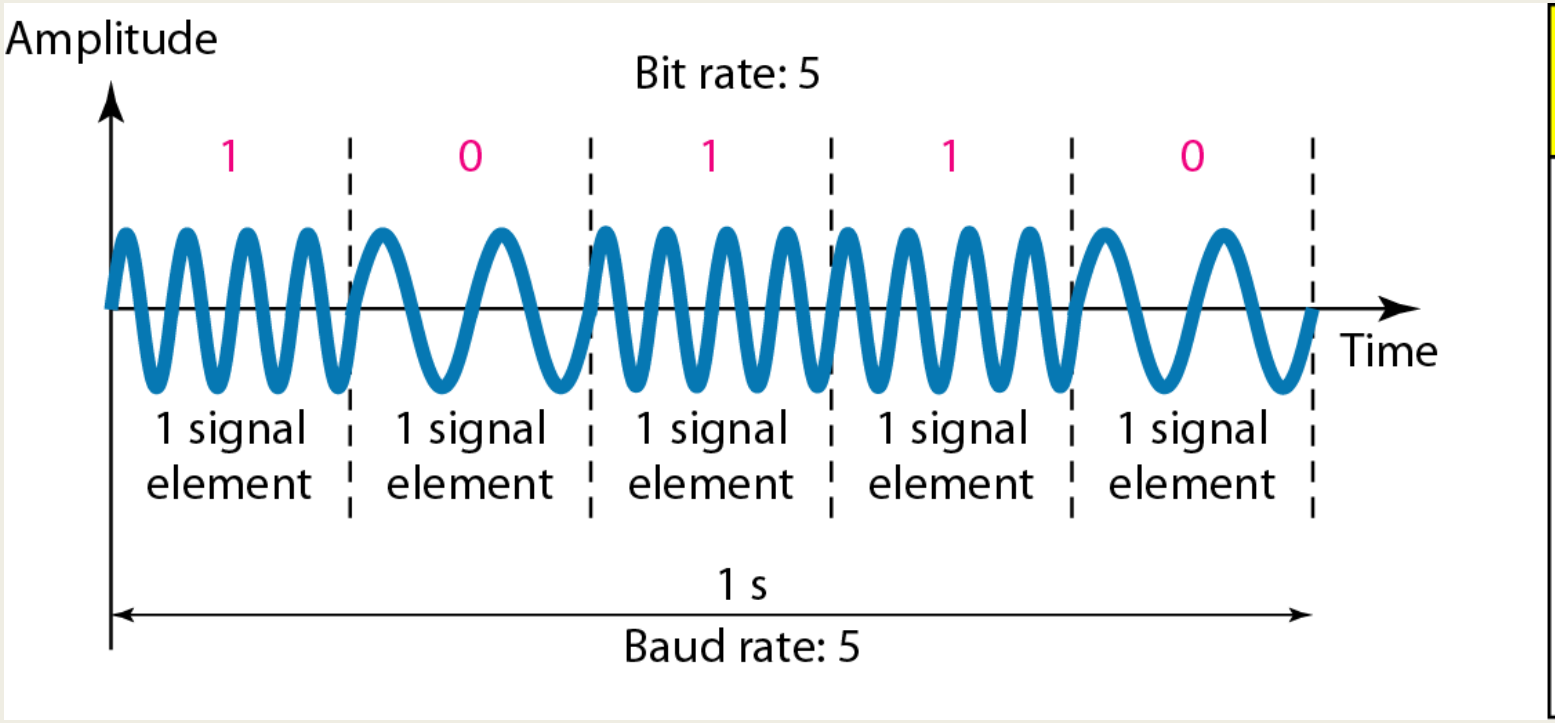
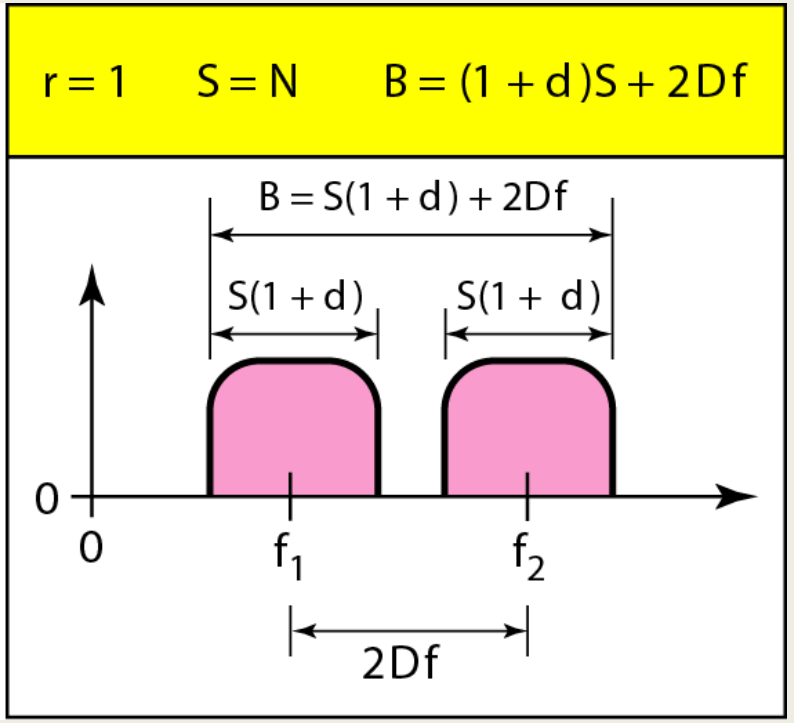
Frequency Shift Keying (FSK)

- The digital data stream changes the frequency of the carrier signal, f_c.





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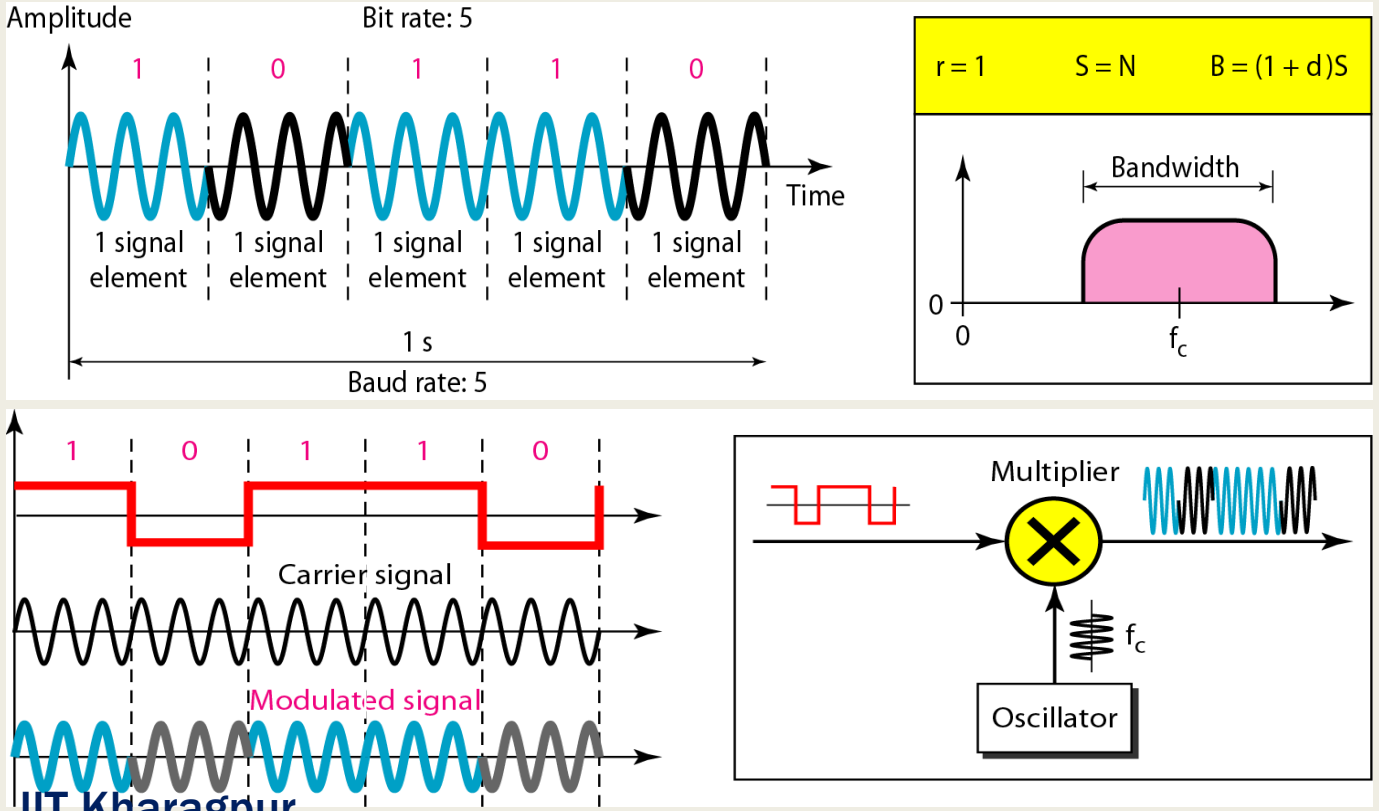
Coherent and Non Coherent (FSK)

- In a non-coherent FSK scheme, when we change from one frequency to the other, we do not adhere to the current phase of the signal.
- In coherent FSK, the switch from one frequency signal to the other only occurs at the same phase in the signal.

Phase Shift Keying

- We vary the phase shift of the carrier signal to represent digital data.
- PSK is much more robust than ASK as it is not that vulnerable to noise, which changes amplitude of the signal.



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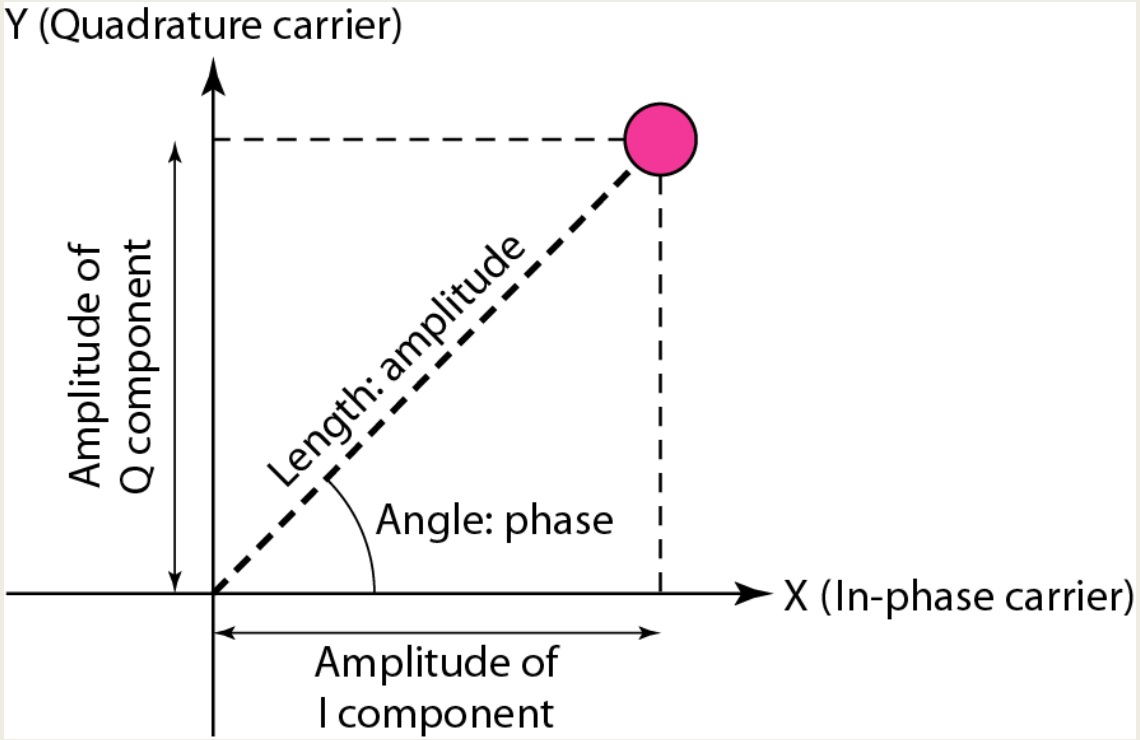
Binary Phase Shift Keying

- Binary Phase-shift keying (BPSK) is a digital modulation scheme that conveys data by changing, or modulating, two different phase s of a reference signal (the carrier wave).
- This gives maximum phase-separation between adjacent points and thus the best immunity to corruption.
- Used in various wireless standards such as CDMA, WiMAX (16d, 16e), WLAN 11a, 11b, 11g, 11n, Satellite, DVB, Cable modem etc.

Constellation Diagrams

- A constellation diagram helps us to define the amplitude and phase of a signal when we are using two carriers, one in quadrature of the other.
- The X-axis represents the in-phase carrier and the Y-axis represents quadrature carrier.



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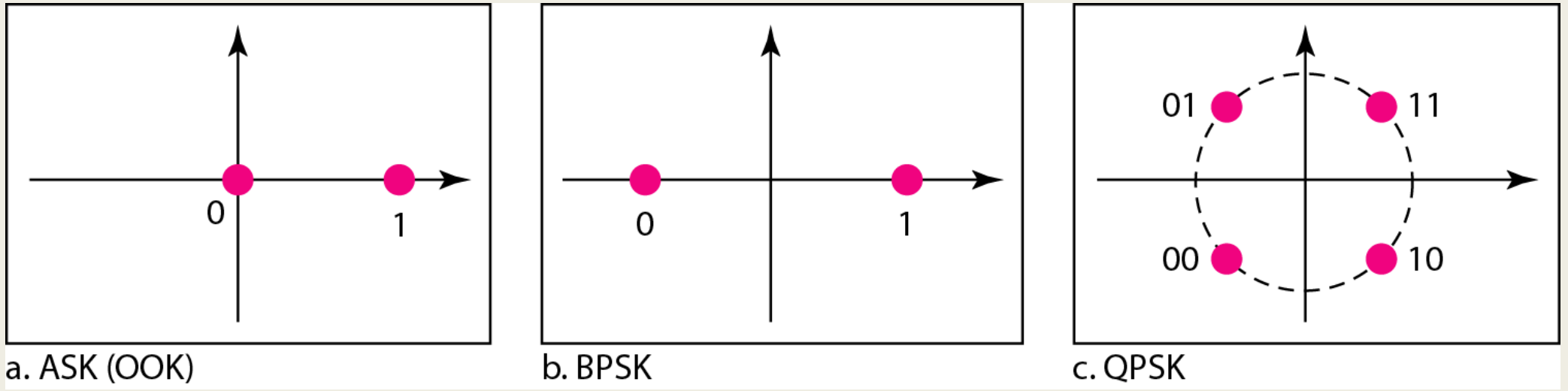
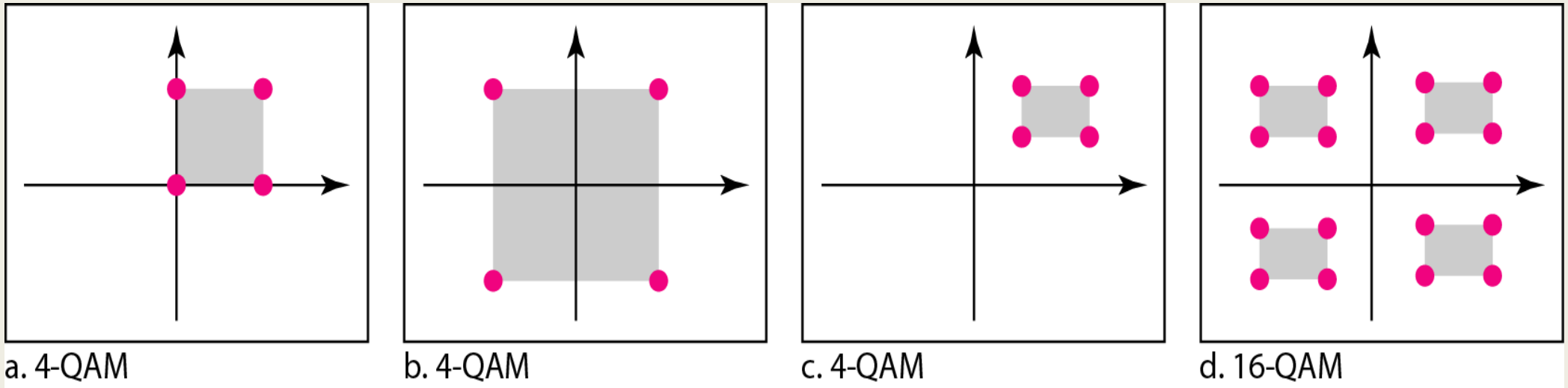


a. ASK (OOK) b. BPSK c. QPSK



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

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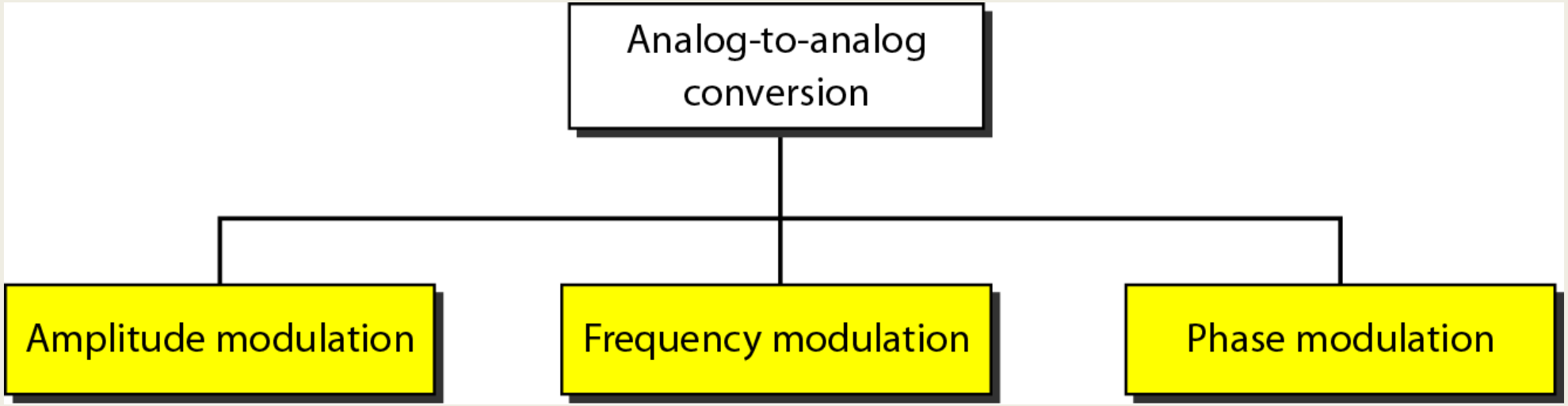
Analog to Analog Conversion

- Analog-to-analog conversion is the representation of analog information by an analog signal.
- One may ask why we need to modulate an analog signal; it is already analog.
- Modulation is needed if the medium is bandpass in nature or if only a bandpass channel is available to us.



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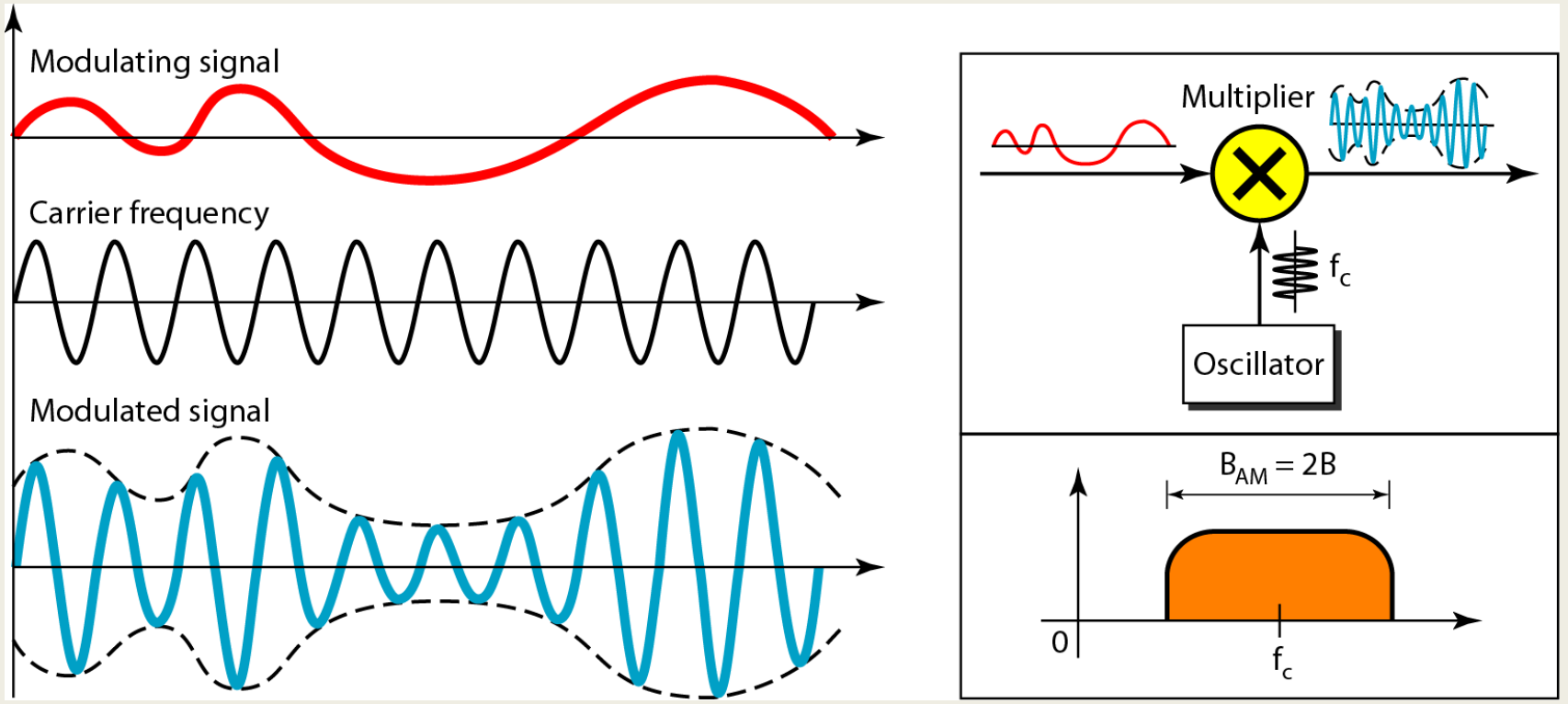
Amplitude Modulation

- A carrier signal is modulated only in amplitude value.
- The modulating signal is the envelope of the carrier.
- The required bandwidth is 2B, where B is the bandwidth of the modulating signal.



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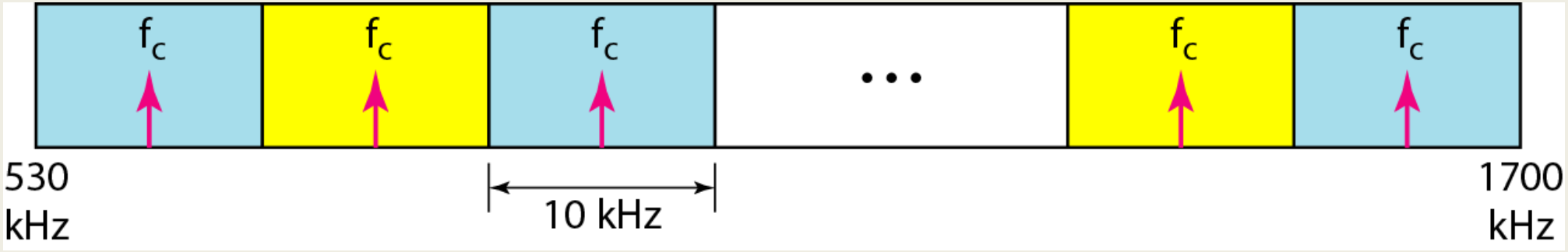
- Since on both sides of the carrier frequency f_c, the spectrum is identical, we can discard one half, thus requiring a smaller bandwidth for transmission.

- The band allocation is as:



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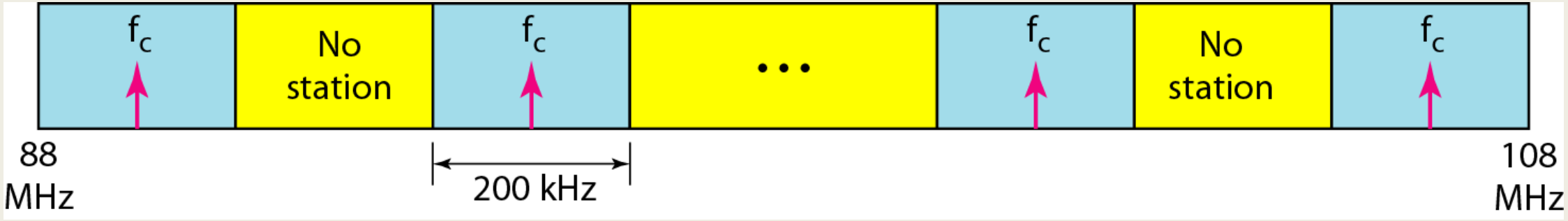
Frequency Modulation

- The modulating signal changes the freq. f_c of the carrier signal.
- The bandwidth for FM is high.
- It is approx. 10x the signal frequency.
- The FM band allocation is:



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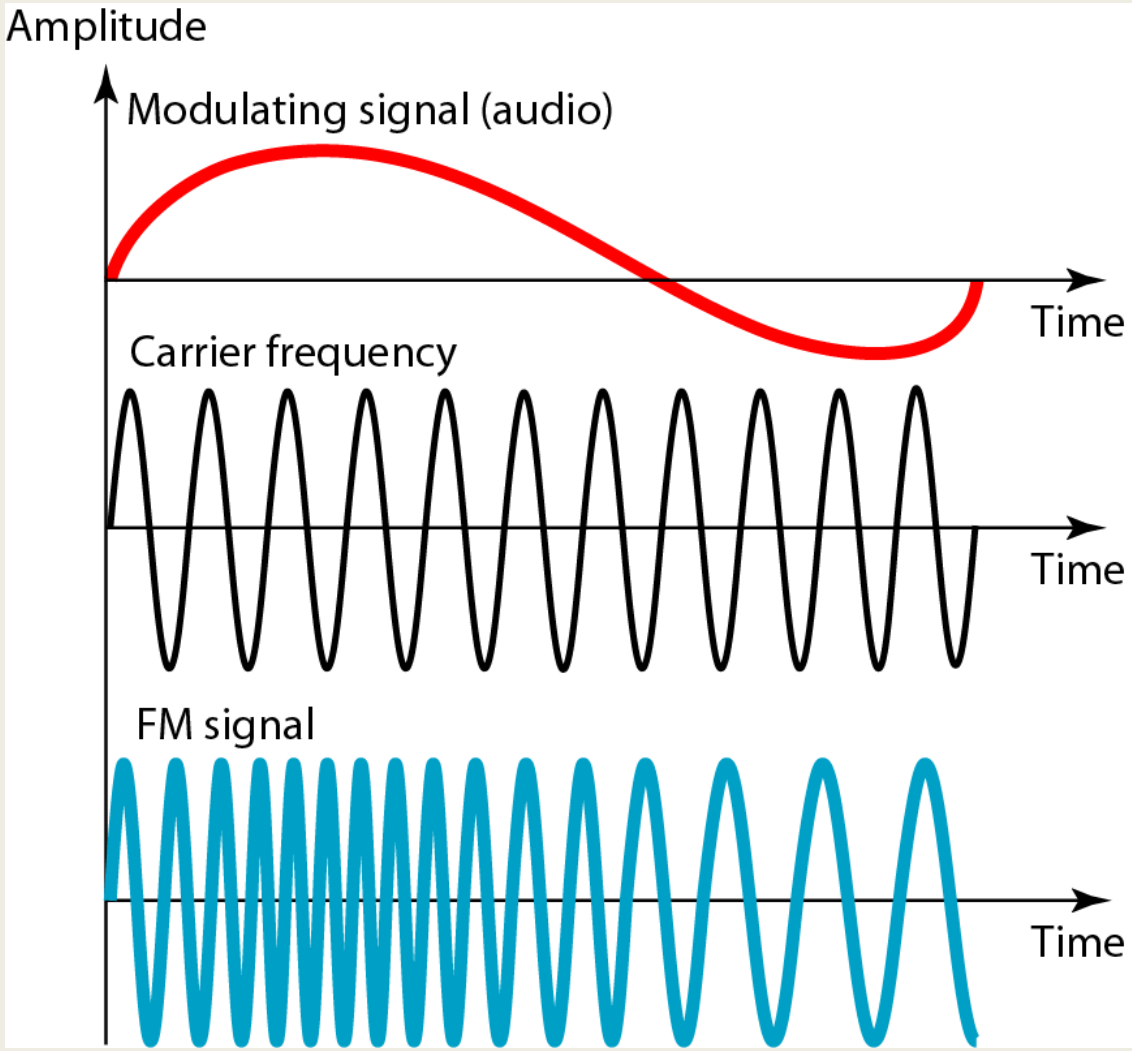

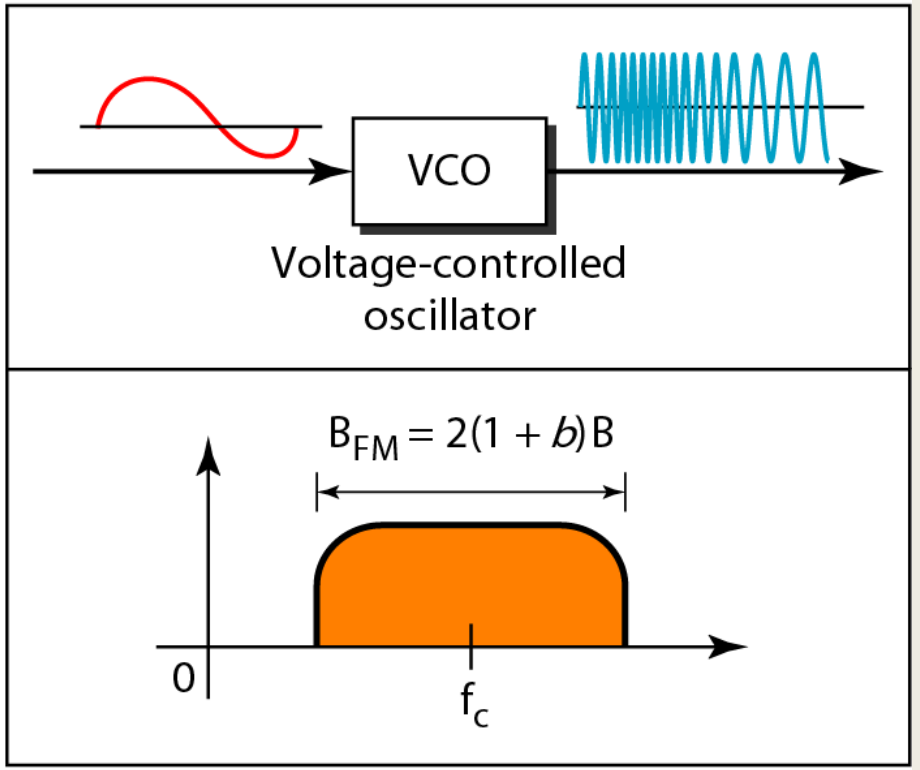

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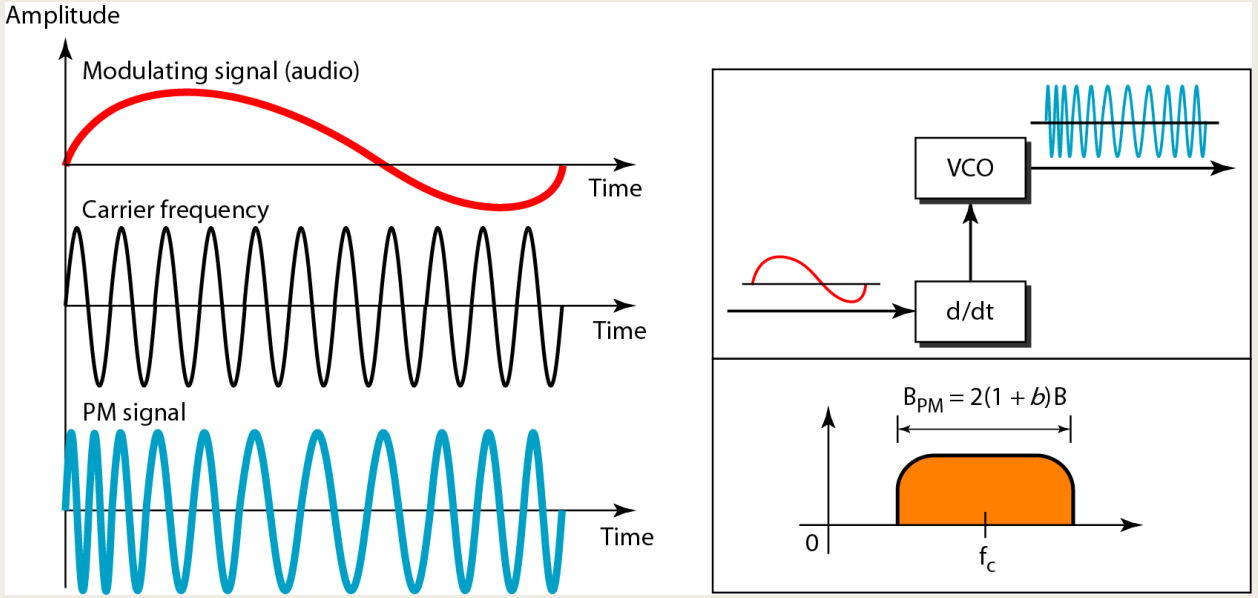
Phase Modulation

- The modulating signal only changes the phase of the carrier signal.
- The phase change manifests itself as a frequency change but the instantaneous frequency change is proportional to the derivative of the amplitude.
- The bandwidth is higher than for AM.



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Thank You!!!