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Keep progressing to attain a higher self.

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CAP275: Data Communication and Networking

Lecture # 10
Physical Layer Multiplexer and De Multiplexer

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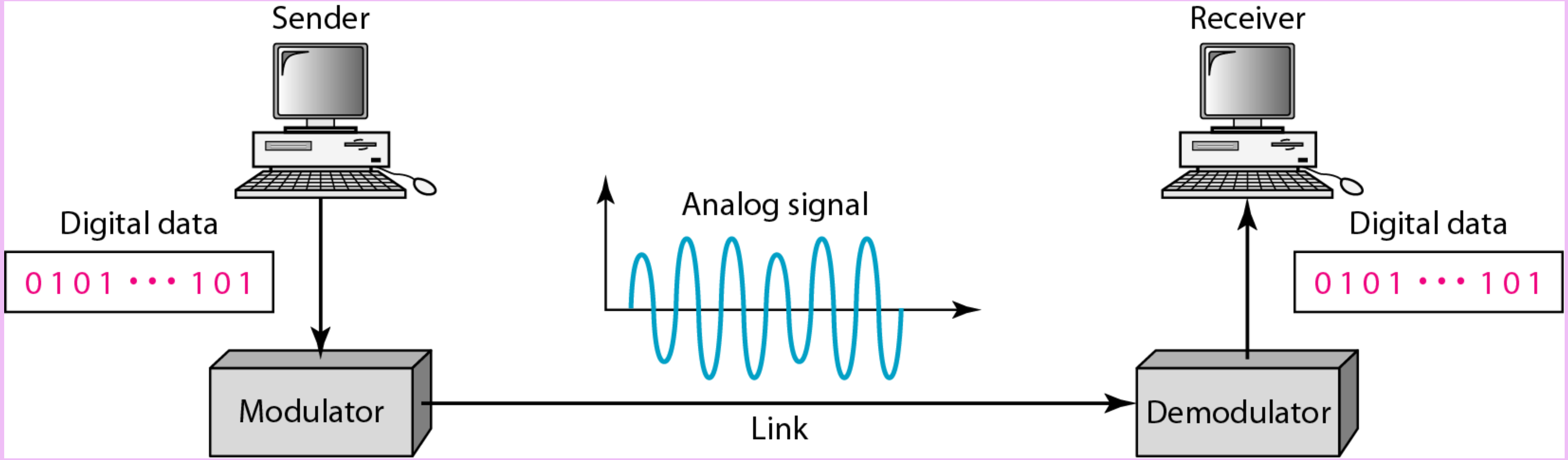
Digital to Analog Conversion

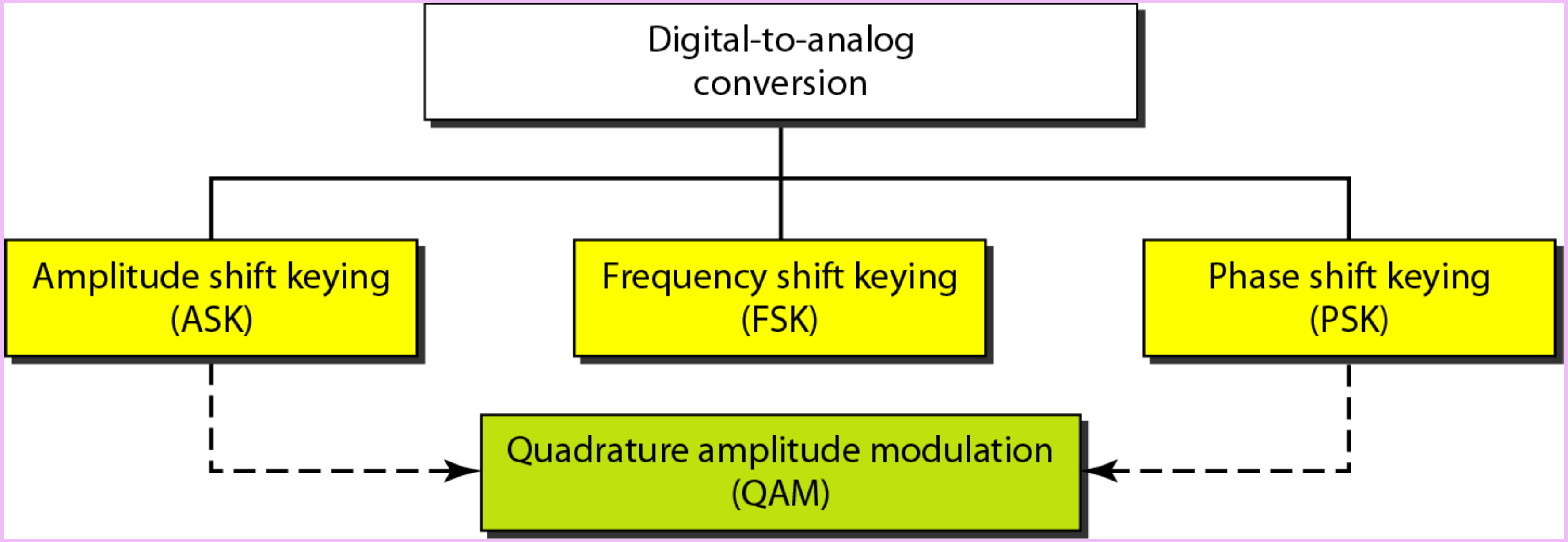
Digital data needs to be carried on an analog signal.

A carrier signal (frequency fc) 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.



Types of Digital-to-Analog Conversion



- 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.

An analog signal carries 4 bits per signal element. If 1000 signal elements are sent per second, find the bit rate.

Solution

In this case, r = 4, S = 1000, and N is unknown. We can find the value of N from

$$S = N \times \frac{1}{r} \qquad \text{or} \qquad N = S \times r = 1000 \times 4 = 4000 \text{ bps}$$

An analog signal has a bit rate of 8000 bps and a baud rate of 1000 baud. How many data elements are carried by each signal element? How many signal elements do we need?

Solution

In this example, S = 1000, N = 8000, and r and L are unknown. We find first the value of r and then the value of L.

$$S = N \times \frac{1}{r} \quad \rightarrow \quad r = \frac{N}{S} = \frac{8000}{1000} = 8 \text{ bits/baud}$$

$$r = \log_2 L \quad \rightarrow \quad L = 2^r = 2^8 = 256$$

Amplitude Shift Keying (ASK)

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.

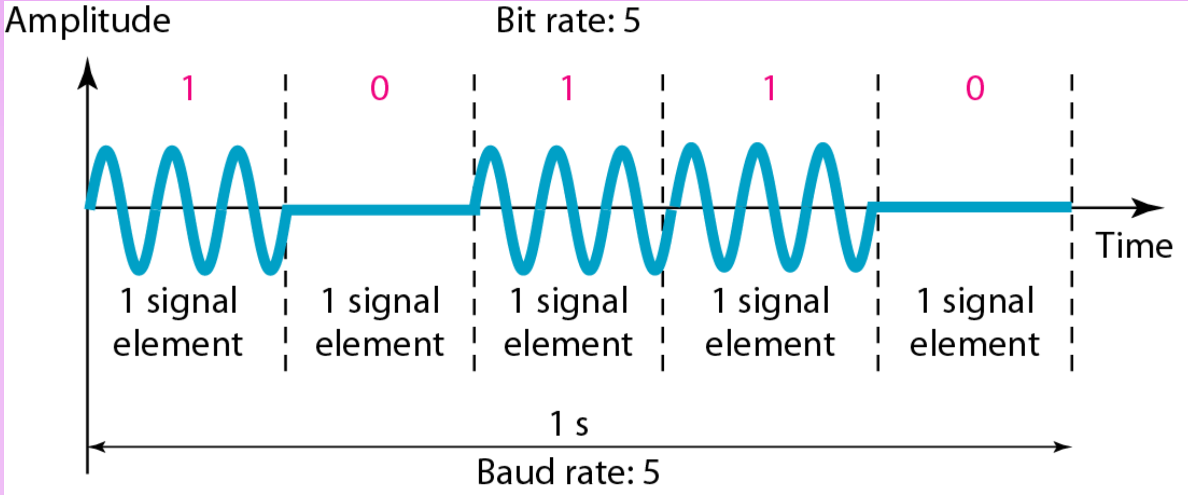
The line encoding will determine the values of the analog waveform to reflect the digital data being carried.

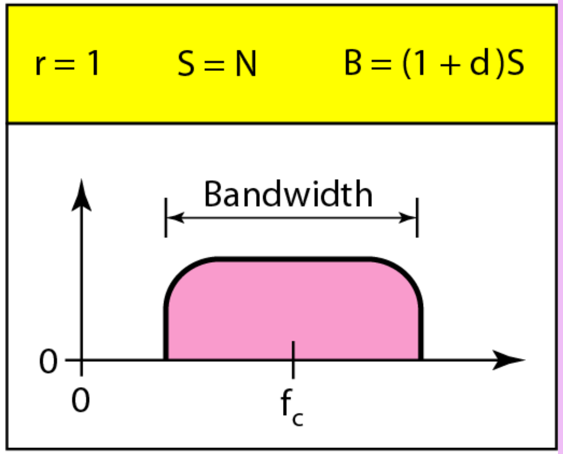
Bandwidth of ASK

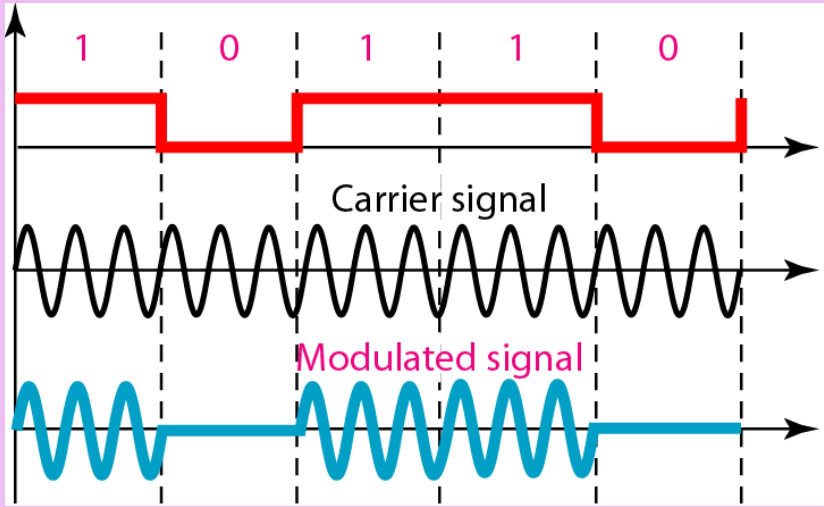
The bandwidth B of ASK is proportional to the signal rate S.
B = (1+d)S

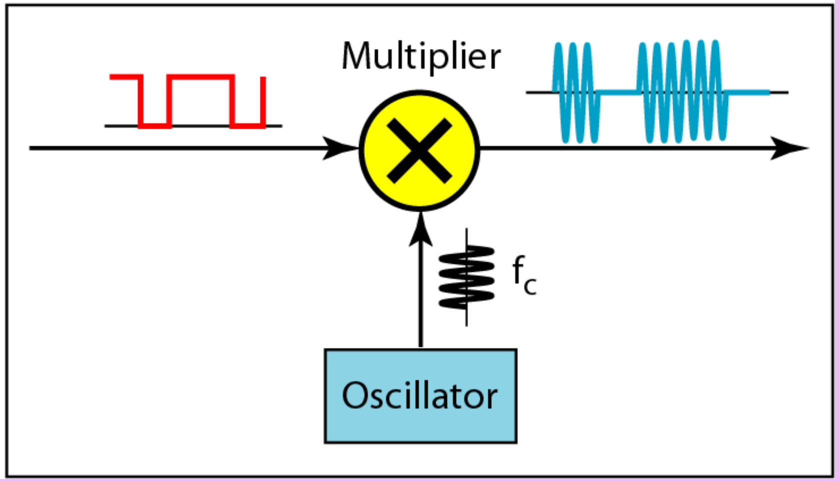
“d” is due to modulation and filtering, lies between 0 and 1.

Binary Amplitude Shift Keying









Frequency Shift Keying

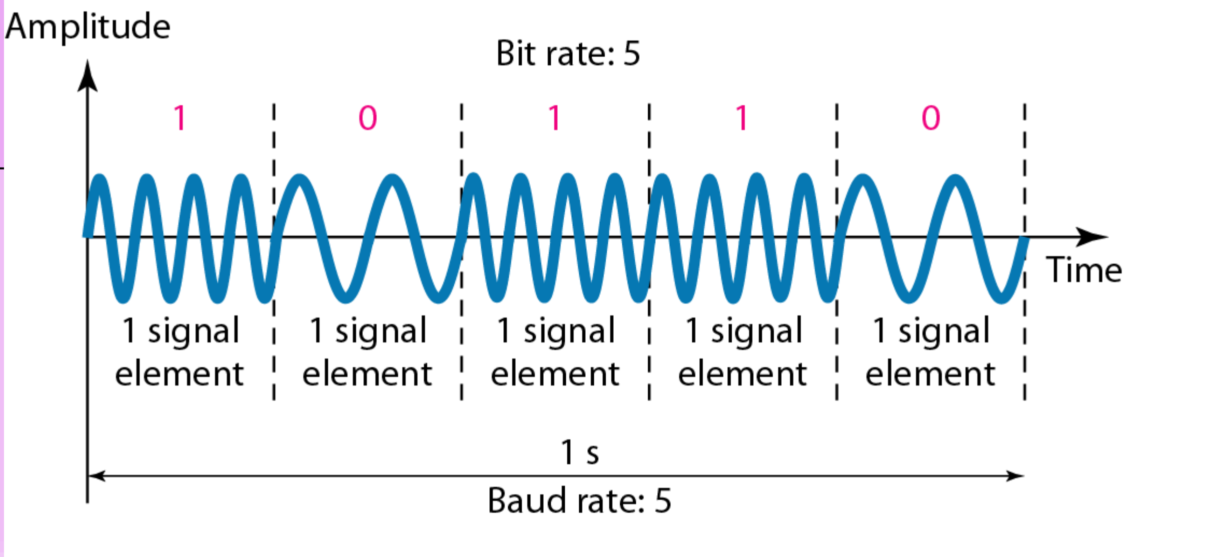
The digital data stream changes the frequency of the carrier signal, fc.

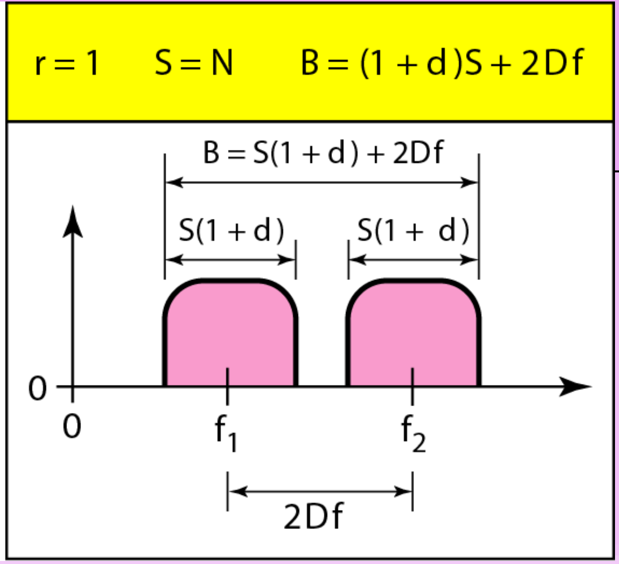
For example, a "1" could be represented by $f1=fc+\Delta f$, and a "0" could be represented by $f2=fc-\Delta f$.

Bandwidth of FSK

If the difference between the two frequencies (f1 and f2) is $2\Delta f$, then the required BW B will be:

$B = (1+d)xS + 2\Delta f$





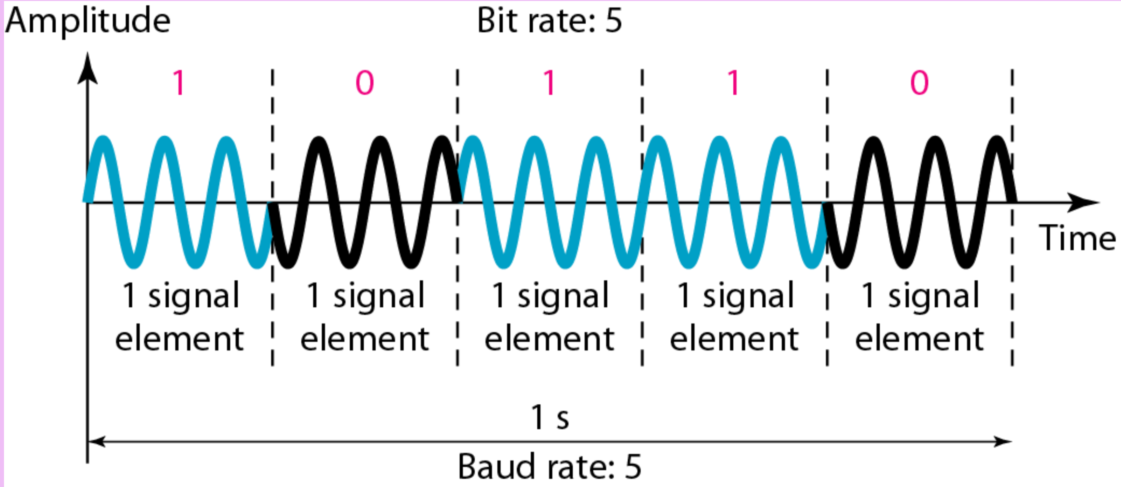
Phase Shift Keyeing

We vary the phase shift of the carrier signal to represent digital data.

The bandwidth requirement, B is:

$$B = (1+d)xS$$

PSK is much more robust than ASK as it is not that vulnerable to noise, which changes amplitude of the signal.



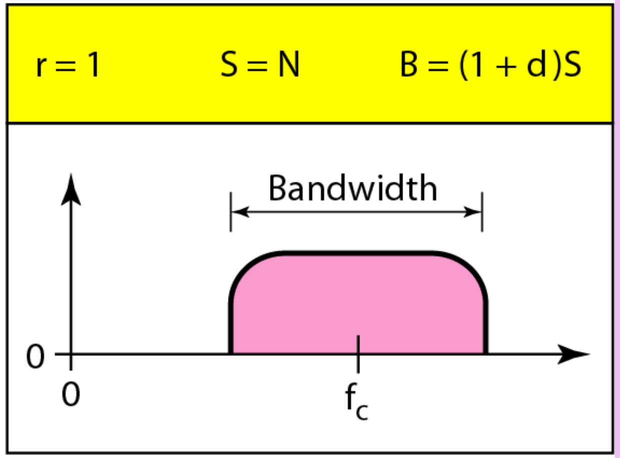
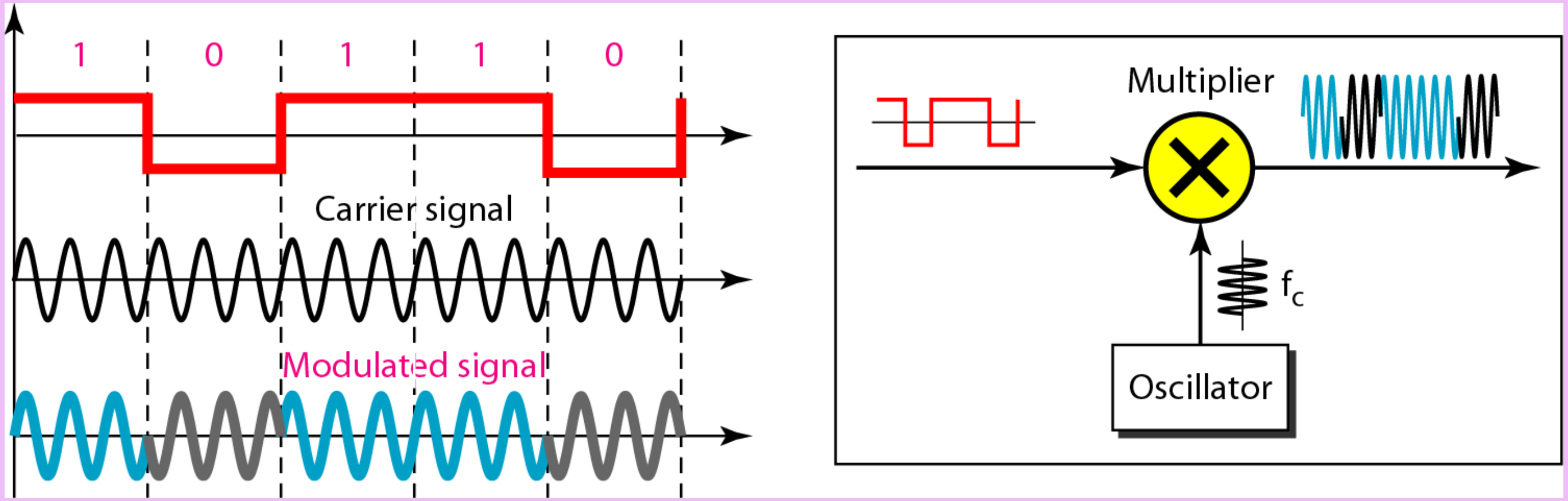


Figure 5.10 *Implementation of PSK*



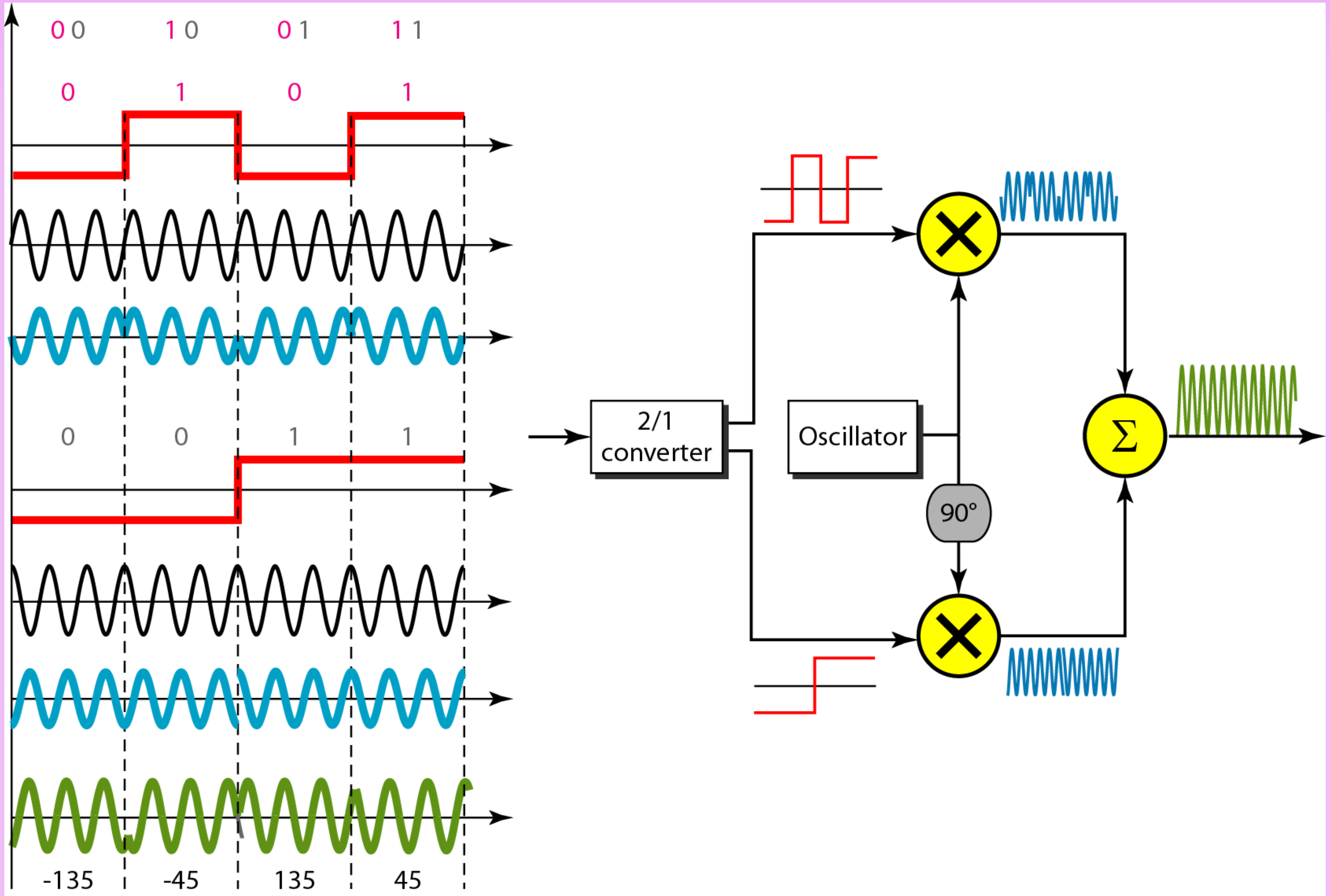
Quadrature PSK

To increase the bit rate, we can code 2 or more bits onto one signal element.

In QPSK, we parallelize the bit stream so that every two incoming bits are split up and PSK a carrier frequency. One carrier frequency is phase shifted 90^o from the other - in quadrature.

The two PSKed signals are then added to produce one of 4 signal elements. L = 4 here.

QPSK and its implementation



Note

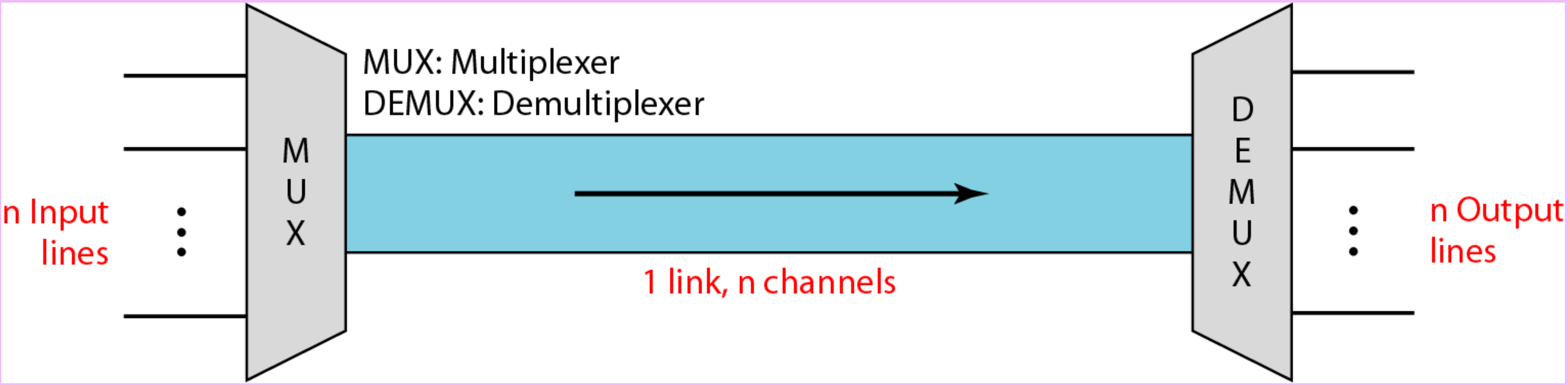
Quadrature amplitude modulation is a combination of ASK and PSK.

MULTIPLEXING

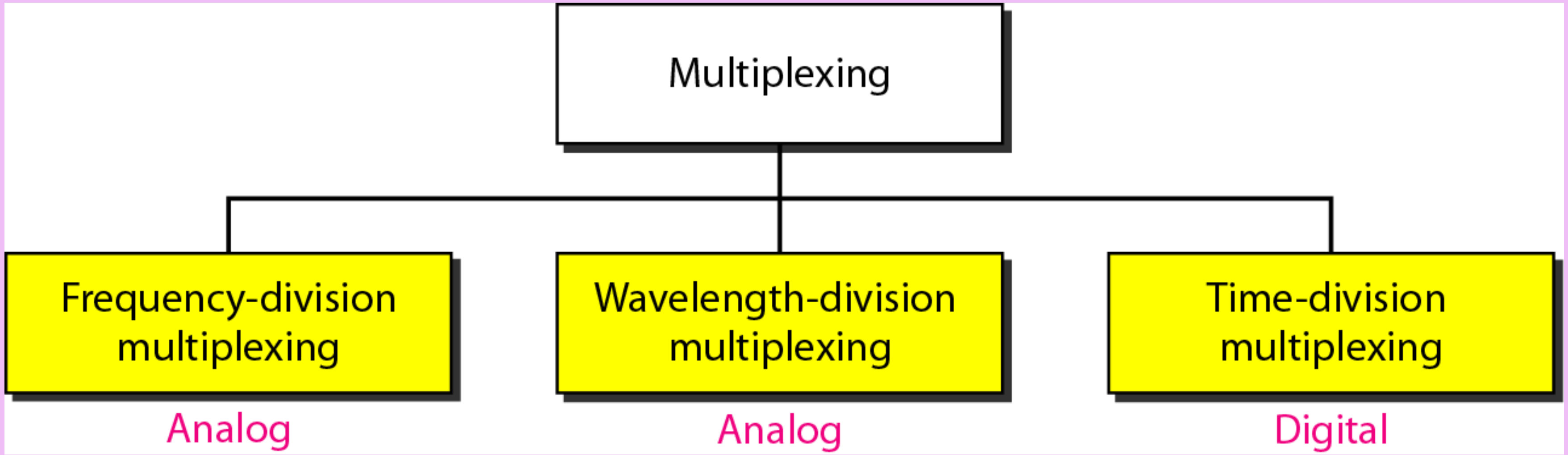
- Whenever the bandwidth of a medium linking two devices is greater than the bandwidth needs of the devices, the link can be shared.
- Multiplexing is the set of techniques that allows the (simultaneous) transmission of multiple signals across a single data link.
- As data and telecommunications use increases, so does traffic.

  - Frequency-Division Multiplexing
  - Wavelength-Division Multiplexing
  - Time-Division Multiplexing

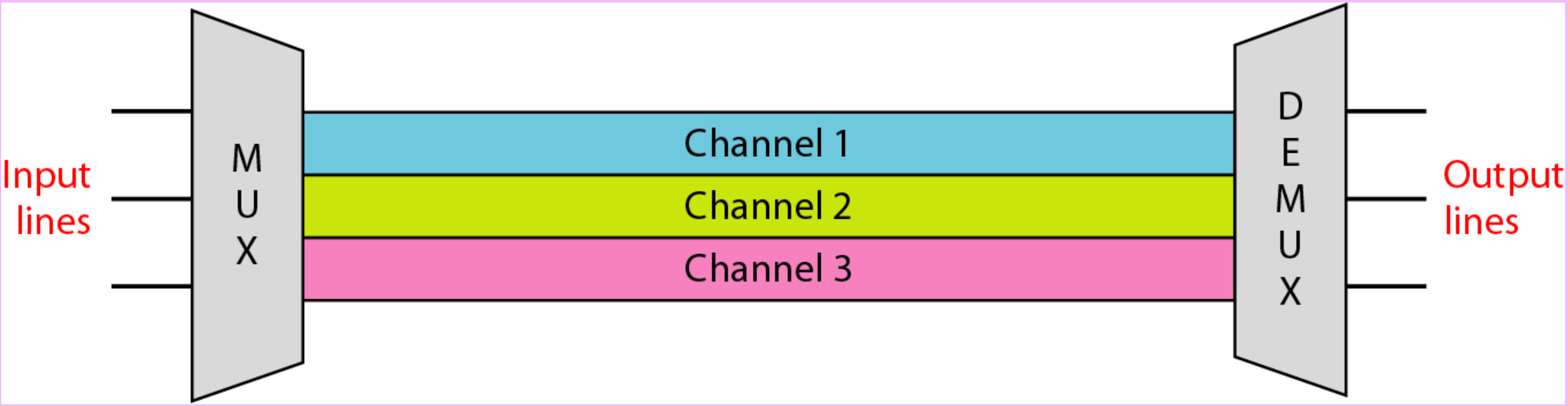
Dividing a link into channels

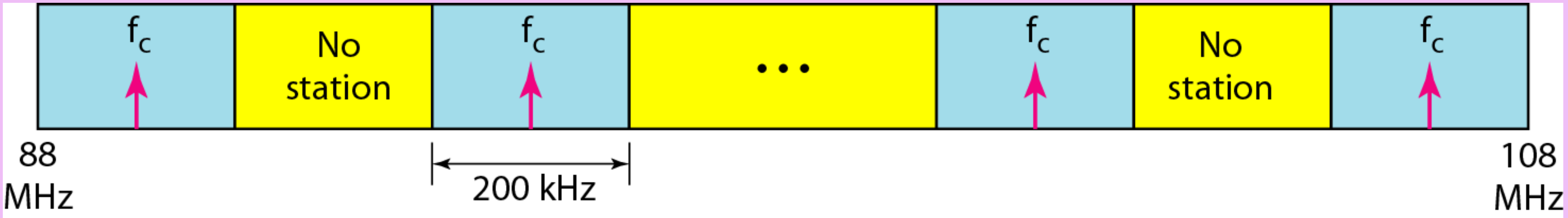


Categories of multiplexing

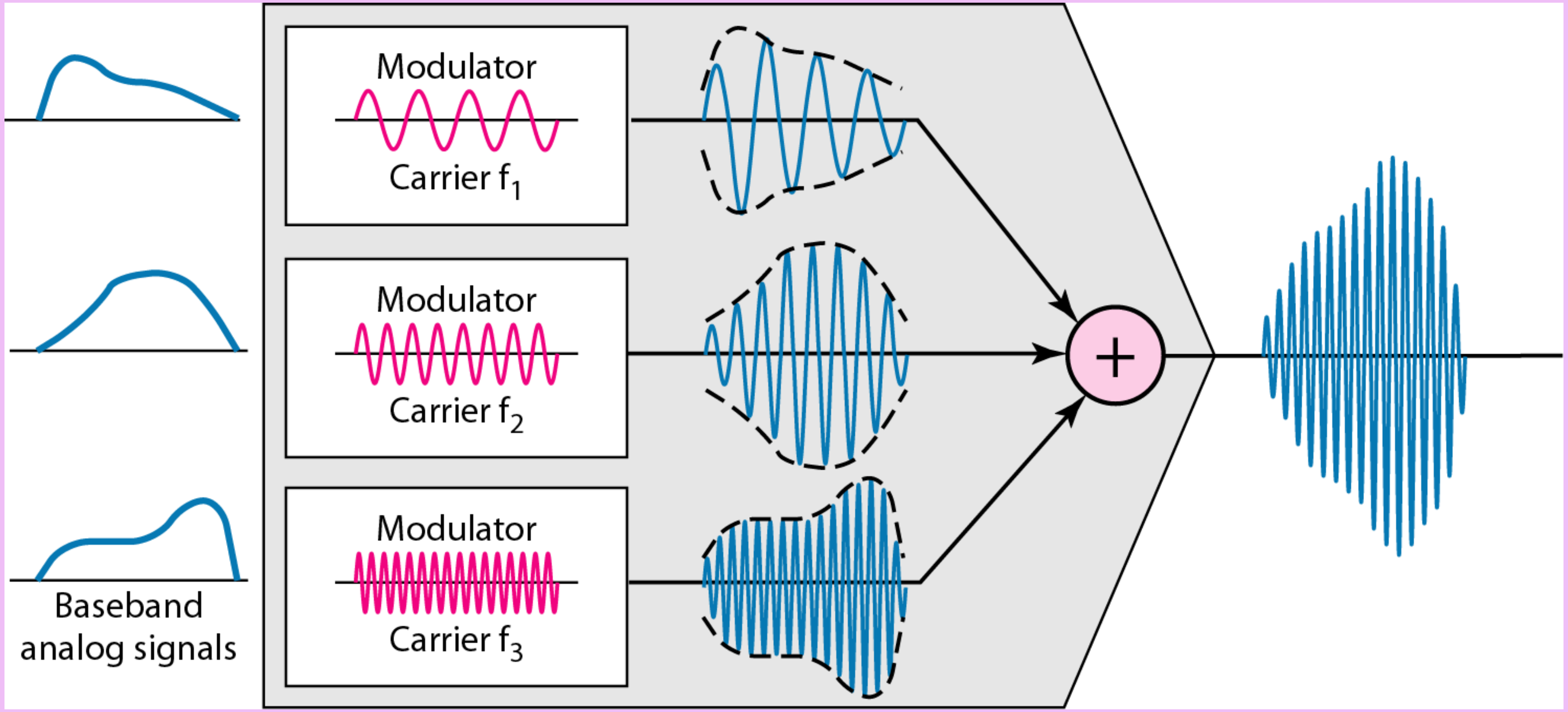


Frequency-division multiplexing (FDM)



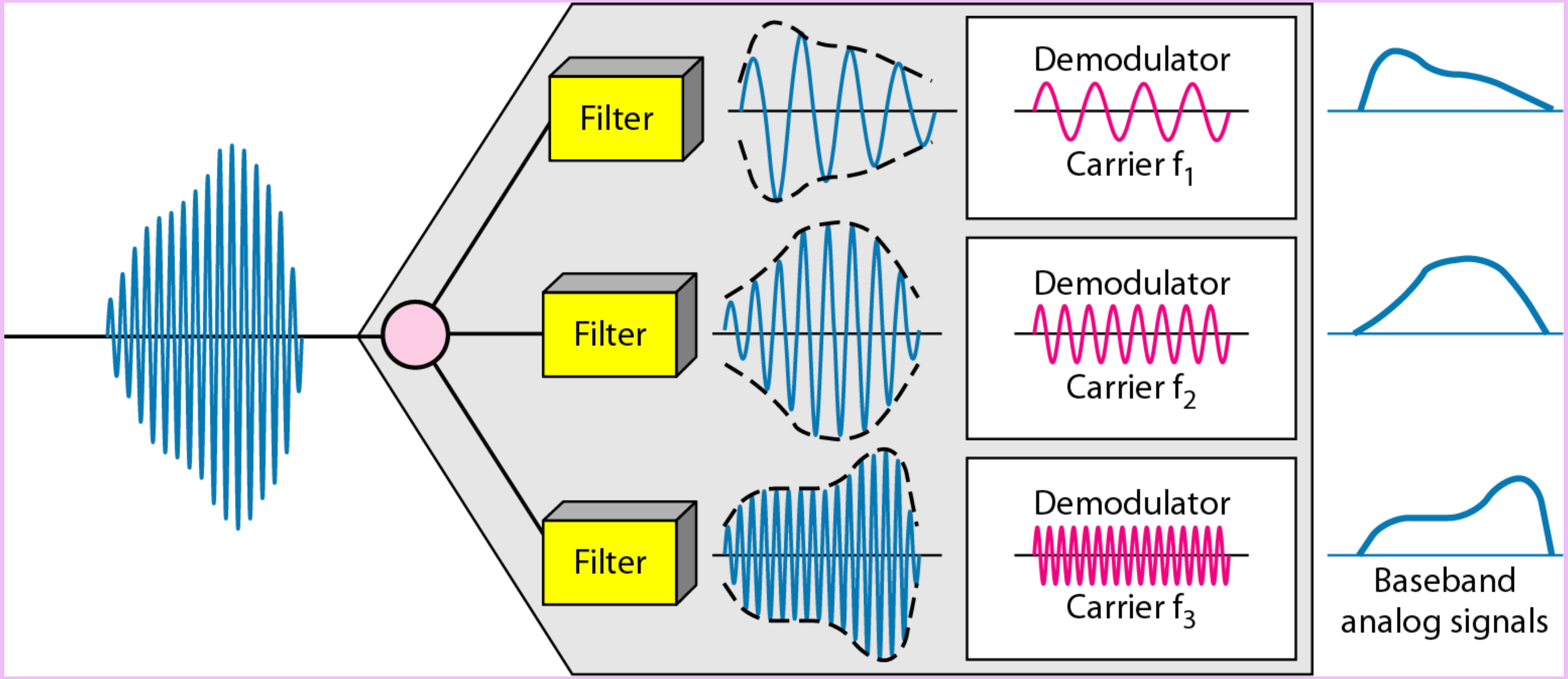


FDM Process



Modulator
Carrier f_1
Modulator
Carrier f_2
Modulator
Carrier f_3
+
Baseband
analog signals

FDM demultiplexing



Assume that a voice channel occupies a bandwidth of 4 kHz. We need to combine three voice channels into a link with a bandwidth of 12 kHz, from 20 to 32 kHz. Show the configuration, using the frequency domain. Assume there are no guard bands.

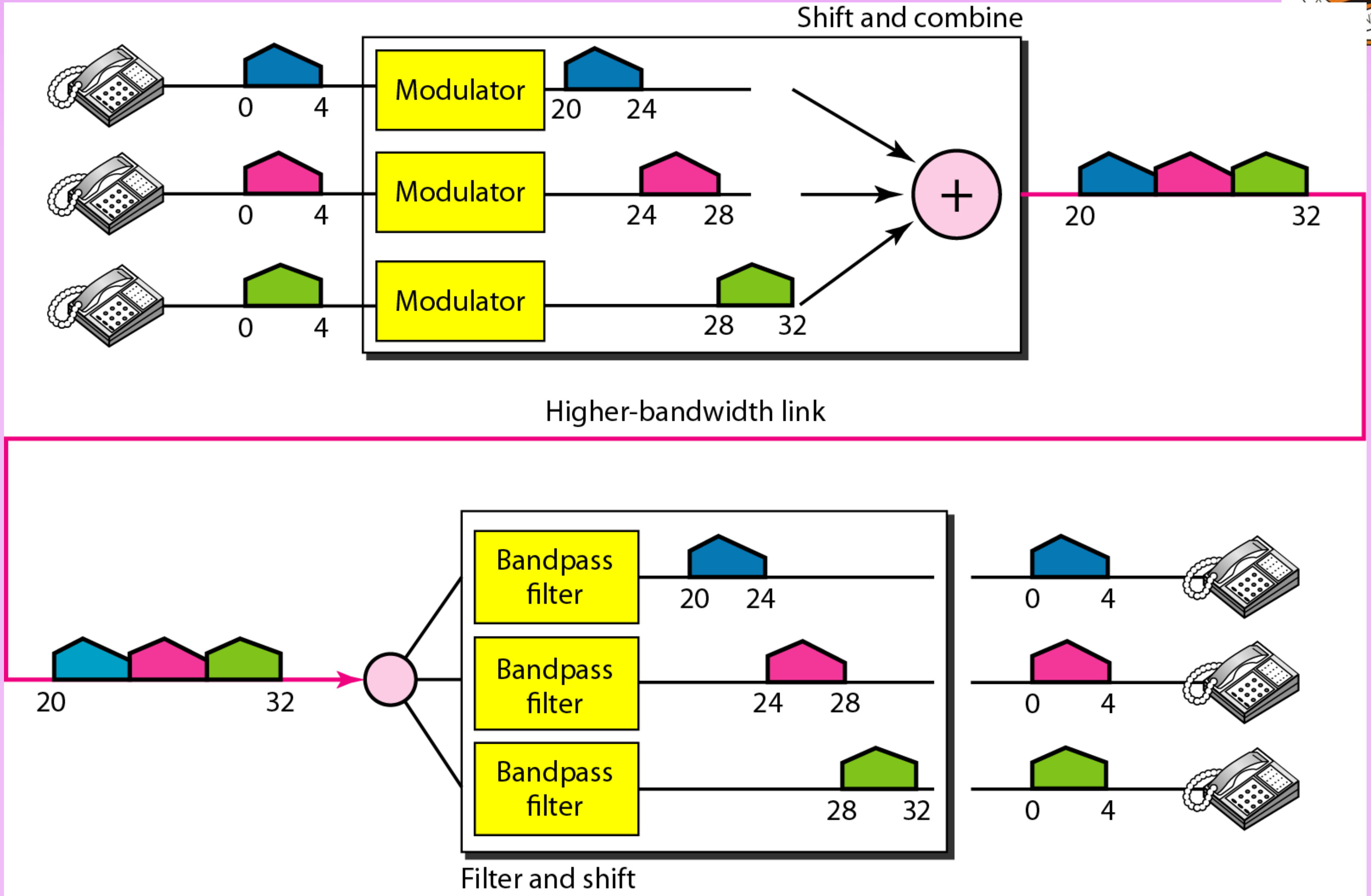
Solution

We shift (modulate) each of the three voice channels to a different bandwidth, as shown in Figure. We use

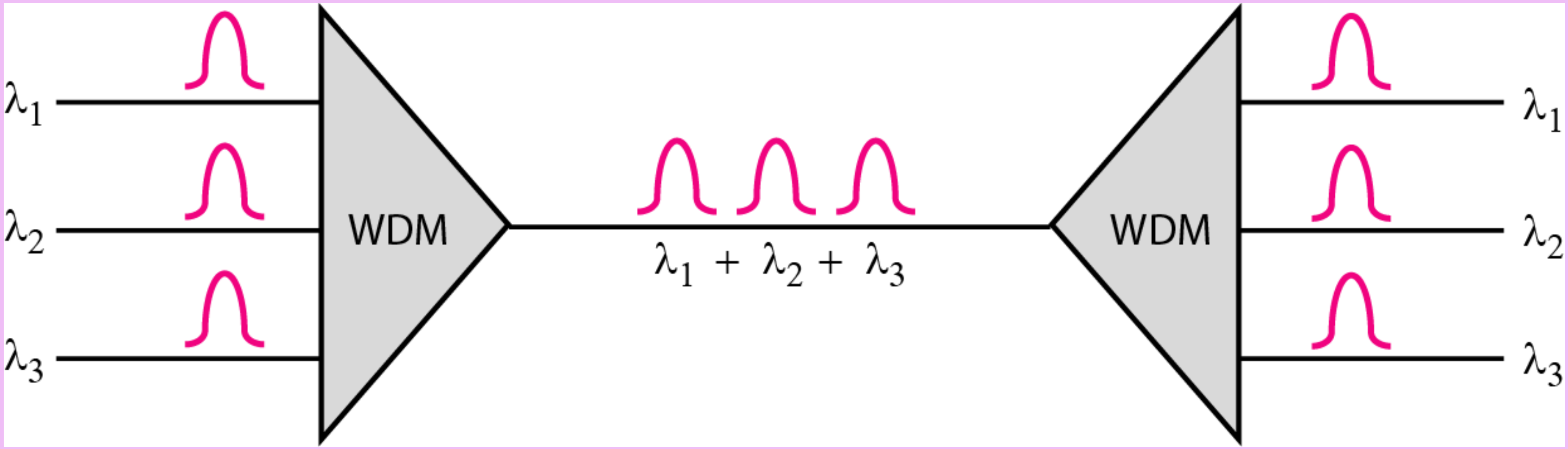
- the 20 to 24 kHz bandwidth for the first channel,
- the 24 to 28 kHz bandwidth for the second channel, and
- the 28 to 32 kHz bandwidth for the third one.

Then we combine them.

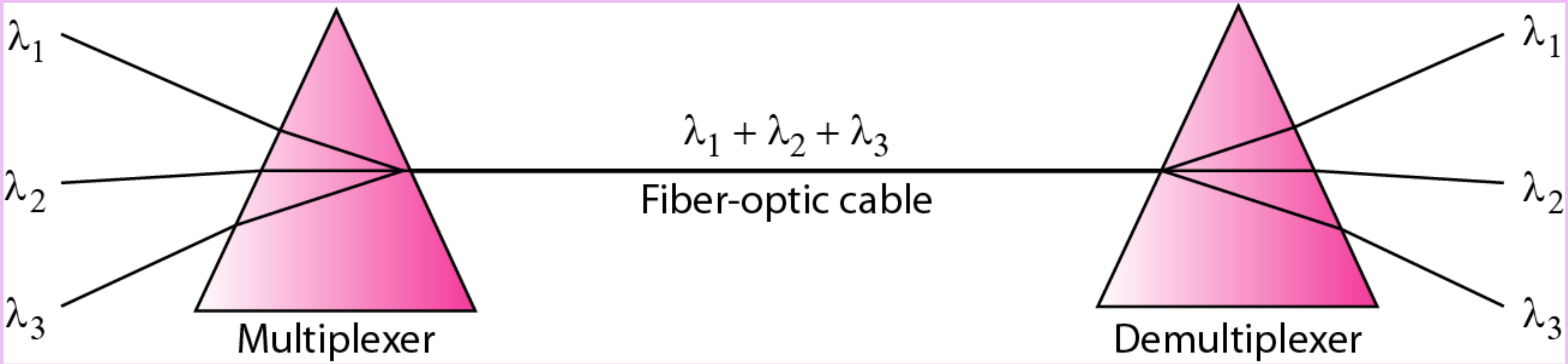
Figure 6.6 *Example 6.1*



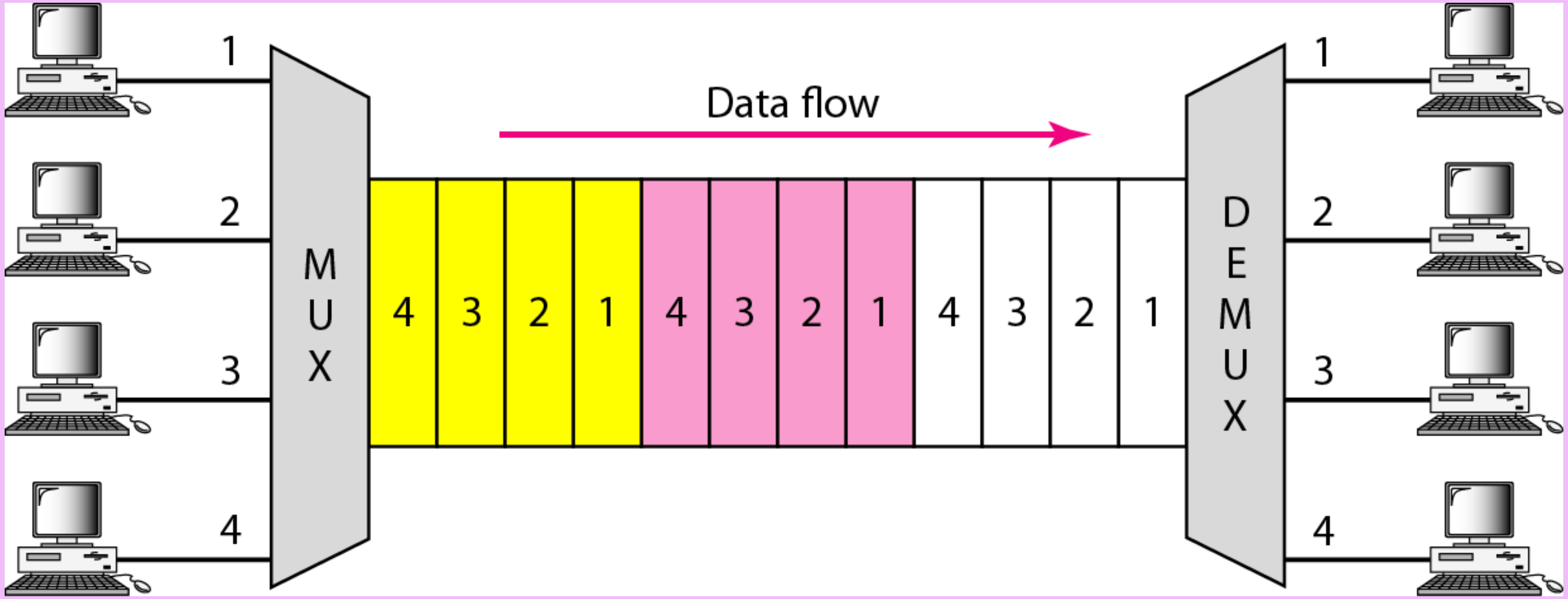
Wavelength-Division Multiplexing (WDM)



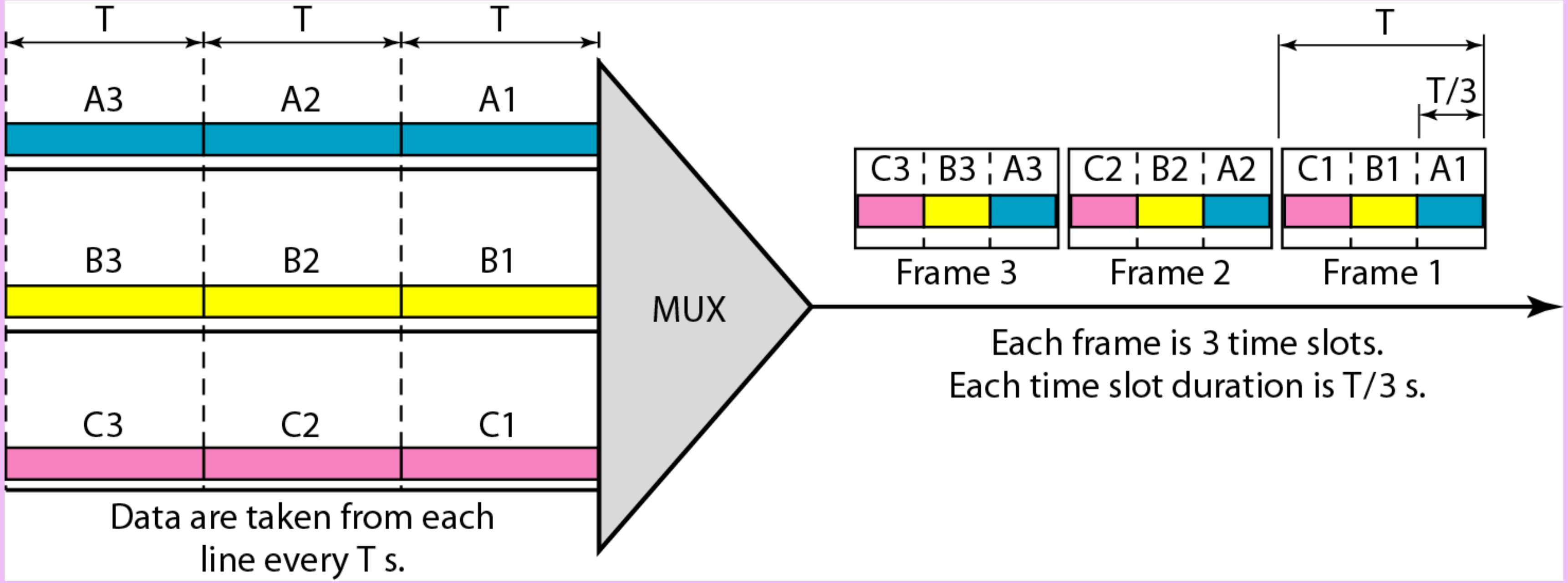
Prisms in wavelength-division multiplexing and demultiplexing



Time Division Multiplexing (*TDM)*



Time-Division Multiplexing



Multiple Choice Questions

1: ASK, PSK, FSK, and QAM are examples of ________ conversion.

a. digital-to-digital

b. digital-to-analog

c. analog-to-analog

d. analog-to-digital

2: AM and FM are examples of ________ conversion.

a. digital-to-digital

b. digital-to-analog

c. analog-to-analog

d. analog-to-digital

Multiple Choice Questions

1: ASK, PSK, FSK, and QAM are examples of ________ conversion.

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d. analog-to-digital

2: AM and FM are examples of ________ conversion.

a. digital-to-digital

b. digital-to-analog

c. analog-to-analog

d. analog-to-digital

Multiple Choice Questions

3: In QAM, both _______ of a carrier frequency are varied.

a. frequency and amplitude

b. phase and frequency

c. amplitude and phase

d. none of the above

See you in next class