CHAPTER 5 (corrisponde al cap. 4 italiano)

Analog Transmission

Solutions to Review Questions and Exercises

Review Questions

1. Normally, ***analog transmission*** refers to the transmission of analog signals using a band-pass channel. Baseband digital or analog signals are converted to a complex analog signal with a range of frequencies suitable for the channel.
2. A ***carrier*** is a single-frequency signal that has one of its characteristics (amplitude, frequency, or phase) changed to represent the baseband signal.
3. The process of changing one of the characteristics of an analog signal based on the information in digital data is called ***digital-to-analog conversion***. It is also called modulation of a digital signal. The baseband digital signal representing the digital data modulates the carrier to create a broadband analog signal.
4.
   a. ASK changes the ***amplitude*** of the carrier.
   b. FSK changes the ***frequency*** of the carrier.
   c. PSK changes the ***phase*** of the carrier.
   d. QAM changes both the ***amplitude*** and the ***phase*** of the carrier.
5. We can say that the most susceptible technique is ***ASK*** because the amplitude is more affected by noise than the phase or frequency.
6. A ***constellation diagram*** can help us define the amplitude and phase of a signal element, particularly when we are using two carriers. The diagram is useful when we are dealing with multilevel ASK, PSK, or QAM. In a constellation diagram, a signal element type is represented as a dot. The bit or combination of bits it can carry is often written next to it.The diagram has two axes. The horizontal *X* axis is related to the in-phase carrier; the vertical *Y* axis is related to the quadrature carrier.
7. The two components of a signal are called ***I*** and ***Q***. The I component, called in-phase, is shown on the horizontal axis; the Q component, called quadrature, is shown on the vertical axis.
8. The process of changing one of the characteristics of an analog signal to represent the instantaneous amplitude of a baseband signal is called ***analog-to-analog con-***

version. It is also called the *modulation* of an analog signal; the baseband analog signal modulates the carrier to create a broadband analog signal.

9.
   a. AM changes the ***amplitude*** of the carrier
   b. FM changes the ***frequency*** of the carrier
   c. PM changes the ***phase*** of the carrier

10. We can say that the most susceptible technique is ***AM*** because the amplitude is more affected by noise than the phase or frequency.

Exercises

11. We use the formula **S = (1/r) × N**, but first we need to calculate the value of r for each case.

a. $r = \log_2 2$	= 1	→	S = (1/1) × (2000 bps)	= **2000 baud**
b. $r = \log_2 2$	= 1	→	S = (1/1) × (4000 bps)	= **4000 baud**
c. $r = \log_2 4$	= 2	→	S = (1/2) × (6000 bps)	= **3000 baud**
d. $r = \log_2 64$	= 6	→	S = (1/6) × (36,000 bps)	= **6000 baud**

12. We use the formula **N = r × S**, but first we need to calculate the value of r for each case.

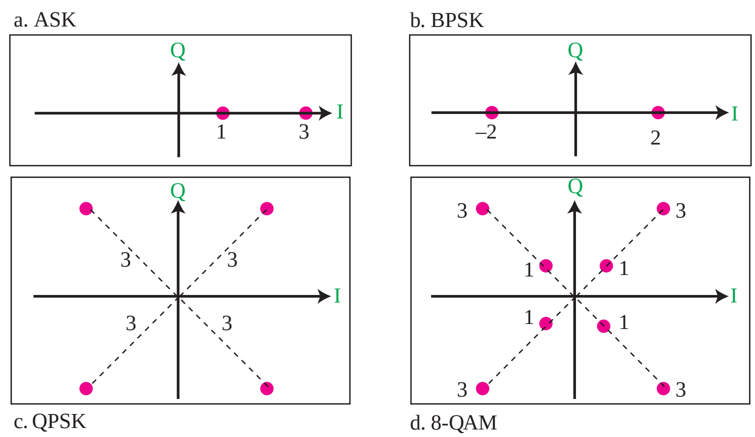
a. $r = \log_2 2$	= 1	→	N = (1) × (1000 bps)	= **1000 bps**
b. $r = \log_2 2$	= 1	→	N = (1) × (1000 bps)	= **1000 bps**
c. $r = \log_2 2$	= 1	→	N = (1) × (1000 bps)	= **1000 bps**
d. $r = \log_2 16$	= 4	→	N = (4) × (1000 bps)	= **4000 bps**

13. We use the formula $\mathbf{r = \log_2 L}$ to calculate the value of r for each case.

a. $\log_2 4$	= 2
b. $\log_2 8$	= 3
c. $\log_2 4$	= 2
d. $\log_2 128$	= 7

14. See Figure 5.1.
   a. We have two signal elements with peak amplitudes 1 and 3. The phase of both signal elements are the same, which we assume to be 0 degrees.
   b. We have two signal elements with the same peak amplitude of 2. However, there must be 180 degrees difference between the two phases. We assume one phase to be 0 and the other 180 degrees.
   c. We have four signal elements with the same peak amplitude of 3. However, there must be 90 degrees difference between each phase. We assume the first phase to be at 45, the second at 135, the third at 225, and the fourth at 315 degrees. Note that this is one out of many configurations. The phases can be at

Figure 5.1 *Solution to Exercise 14*

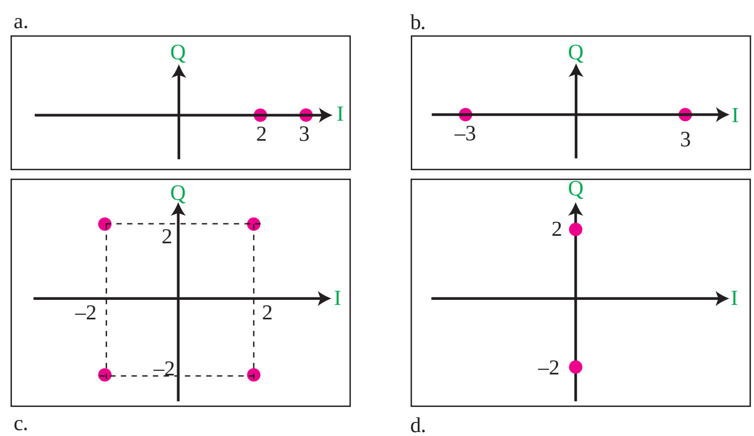


0, 90, 180, and 270. As long as the differences are 90 degrees, the solution is satisfactory.

d. We have four phases, which we select to be the same as the previous case. For each phase, however, we have two amplitudes, 1 and 3 as shown in the figure. Note that this is one out of many configurations. The phases can be at 0, 90, 180, and 270. As long as the differences are 90 degrees, the solution is satisfactory.

15. See Figure 5.2

Figure 5.2 *Solution to Exercise 15*



a. This is ASK. There are two peak amplitudes both with the same phase (0 degrees). The values of the peak amplitudes are $A_1 = 2$ (the distance between the first dot and the origin) and A_2= 3 (the distance between the second dot and the origin).

b. This is BPSK, There is only one peak amplitude (3). The distance between each dot and the origin is 3. However, we have two phases, 0 and 180 degrees.

c. This can be either QPSK (one amplitude, four phases) or 4-QAM (one amplitude and four phases). The amplitude is the distance between a point and the origin, which is $(2^2 + 2^2)^{1/2} = 2.83$.

d. This is also BPSK. The peak amplitude is 2, but this time the phases are 90 and 270 degrees.

16. The number of points define the number of levels, L. The number of bits per baud is the value of r. Therefore, we use the formula $\mathbf{r = log_2 L}$ for each case.

a. $\log_2 2$	= 1
b. $\log_2 4$	= 2
c. $\log_2 16$	= 4
d. $\log_2 1024$	= 10

17. We use the formula $\mathbf{B = (1 + d) \times (1/r) \times N}$, but first we need to calculate the value of r for each case.

a. r = 1	→	B= (1 + 1) × (1/1) × (4000 bps)	= **8000 Hz**
b. r = 1	→	B = (1 + 1) × (1/1) × (4000 bps) + 4 KHz	= **8000 Hz**
c. r = 2	→	B = (1 + 1) × (1/2) × (4000 bps)	= **2000 Hz**
d. r = 4	→	B = (1 + 1) × (1/4) × (4000 bps)	= **1000 Hz**

18. We use the formula $\mathbf{N = [1/(1 + d)] \times r \times B}$, but first we need to calculate the value of r for each case.

a. r = $\log_2 2$ = 1	→	N= [1/(1 + 0)] × 1 × (4 KHz)	= **4 kbps**
b. r = $\log_2 4$=2	→	N = [1/(1 + 0)] × 2 × (4 KHz)	= **8 kbps**
c. r = $\log_2 16$= 4	→	N = [1/(1 + 0)] × 4 × (4 KHz)	= **16 kbps**
d. **r =** $\log_2 64$= 6	→	N = [1/(1 + 0)] × 6 × (4 KHz)	= **24 kbps**

19.

First, we calculate the bandwidth for each channel = (1 MHz) / 10 = 100 KHz. We then find the value of r for each channel:

$$B = (1 + d) \times (1/r) \times (N) \rightarrow r = N / B \rightarrow r = (1 \text{ Mbps}/100 \text{ KHz}) = 10$$

We can then calculate the number of levels: $L = 2^r = 2^{10} =$ **1024.** This means that that we need a **1024-QAM** technique to achieve this data rate.

20. We can use the formula: N = [1/(1 + d)] × r × B = 1 × 6 × 6 MHz = 36 Mbps

21.

a. $B_{AM} = 2 \times B = 2 \times 5$ = **10 KHz**

b. $B_{FM} = \; 2 \times (1 + \beta) \times B = 2 \times (1 + 5) \times 5$ **= 60 KHz**
c. $B_{PM} = \; 2 \times (1 + \beta) \times B = 2 \times (1 + 1) \times 5$ = **20 KHz**

22. We calculate the number of channels, not the number of coexisting stations.

a. n = (1700 - 530) KHz / 10 KHz = **117**
b. n = (108 - 88) MHz / 200 KHz = **100**