Chap#5 (Data communication)

Q#1: Define analog transmission.

Ans: 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.

Q#2:. Define carrier signal and its role in analog transmission.

Ans: A ***carrier*** is a single-frequency signal that has one of its characteristics (amplitude, frequency, or phase) changed to represent the baseband signal.

Q#3. Define digital-to-analog conversion.

Ans: 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.

Q#4. Which characteristics of an analog signal are changed to represent the digital signal in each of the following digital-to-analog conversion?

a. ASK b. FSK c. PSK d. QAM

Ans:. 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.

Q#5. Which of the four digital-to-analog conversion techniques (ASK, FSK, PSK or QAM) is the most susceptible to noise? Defend your answer.

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

Q#6. Define constellation diagram and its role in analog transmission.

Ans:. 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.

Q#7. What are the two components of a signal when the signal is represented on a constellation diagram? Which component is shown on the horizontal axis? Which is shown on the vertical axis?

Ans: The two components of a signal are called ***I*** and ***Q***. The I component, called inphase, is shown on the horizontal axis; the Q component, called quadrature, is shown on the vertical axis.

Q#8. Define analog-to-analog conversion?

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

Q#9. 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

Ans: AM changes the ***amplitude*** of the carrier

b. FM changes the ***frequency*** of the carrier

c. PM changes the ***phase*** of the carrier

Q#10. Which of the three analog-to-analog conversion techniques (AM, FM, or PM) is the most susceptible to noise? Defend your answer.

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

Q11. Calculate the baud rate for the given bit rate and type of modulation.

a. 2000 bps, FSK b. 4000 bps, ASK c. 6000 bps, QPSK d. 36,000 bps, 64-QAM

Ans: We use the formula **$S = (1/r) \times N$**, but first we need to calculate the value of r for each case.

a. $r = \log_2 2 = 1 \rightarrow S = (1/1) \times (2000 \text{ bps}) =$ **2000 baud**

b. $r = \log_2 2 = 1 \rightarrow S = (1/1) \times (4000 \text{ bps}) =$ **4000 baud**

c. $r = \log_2 4 = 2 \rightarrow S = (1/2) \times (6000 \text{ bps}) =$ **3000 baud**

d. $r = \log_2 64 = 6 \rightarrow S = (1/6) \times (36{,}000 \text{ bps}) =$ **6000 baud**

Q12. Calculate the bit rate for the given baud rate and type of modulation.

a. 1000 baud, FSK b. 1000 baud, ASK c. 1000 baud, BPSK d. 1000 baud, 16-QAM

Ans: We use the formula **$N = r \times S$**, but first we need to calculate the value of r for each case.

a. $r = \log_2 2 = 1 \rightarrow N = (1) \times (1000 \text{ bps}) =$ **1000 bps**

b. $r = \log_2 2 = 1 \rightarrow N = (1) \times (1000 \text{ bps}) =$ **1000 bps**

c. $r = \log_2 2 = 1 \rightarrow N = (1) \times (1000 \text{ bps}) =$ **1000 bps**

d. $r = \log_2 16 = 4 \rightarrow N = (4) \times (1000 \text{ bps}) =$ **4000 bps**

Q13. What is the number of bits per baud for the following techniques?

a. ASK with four different amplitudes

b. FSK with 8 different frequencies

c. PSK with four different phases

d. QAM with a constellation of 128 points.

Ans:

We use the formula $r = \log_2 L$ 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. $\log_2 128 = 7$

Q14. Draw the constellation diagram for the following:

a. ASK, with peak amplitude values of 1 and 3

b. BPSK, with a peak amplitude value of 2

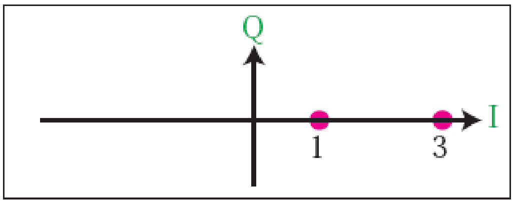
c. QPSK, with a peak amplitude value of 3

d. 8-QAM with two different peak amplitude values, I and 3, and four different phases.

Ans:

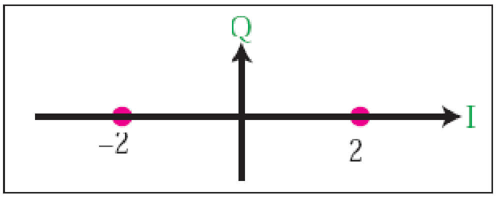
a. We have two signal elements with peak amplitudes 1 and 3. The phase of both signal elements are the same, which we assume to be 0 degrees.

a. ASK

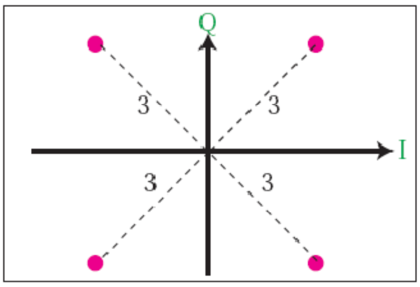


b. We have two signal elements with the same peak amplitude of 2. However, there must be 180 degrees difference between the two phases. We assume one phase to be 0 and the other 180 degrees.

b. BPSK

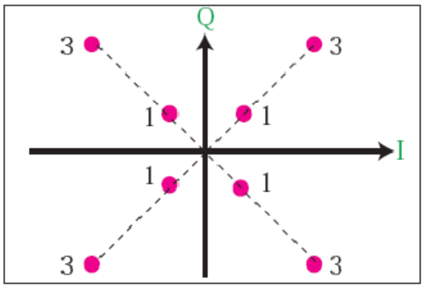


c. We have four signal elements with the same peak amplitude of 3. However, there must be 90 degrees difference between each phase. We assume the first phase to be at 45, the second at 135, the third at 225, and the fourth at 315 degrees. Note that this is one out of many configurations. The phases can be at 0, 90, 180, and 270. As long as the differences are 90 degrees, the solution is satisfactory.



c. QPSK

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.



d. 8-QAM

Q15. Draw the constellation diagram for the following cases. Find the peak amplitude value for each case and define the type of modulation (ASK, FSK, PSK, or QAM). The numbers in parentheses define the values of I and Q respectively.

a. Two points at (2, 0) and (3, 0).

b. Two points at (3, 0) and (-3, 0).

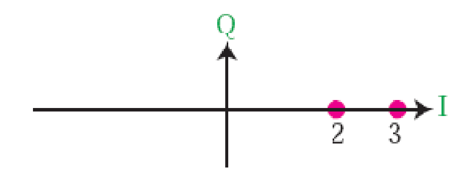
c. Four points at (2, 2), (-2, 2), (-2, -2), and (2, -2).

d. Two points at (0 , 2) and (0, -2).

Ans:

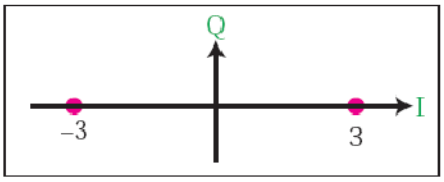
a. This is ASK. There are two peak amplitudes both with the same phase (0 degrees). The values of the peak amplitudes are A1 = 2 (the distance between the first dot and the origin) and A2= 3 (the distance between the second dot and the origin).

a.

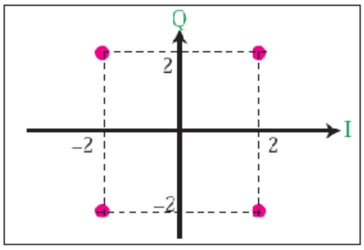


b. This is BPSK, There is only one peak amplitude (3). The distance between each dot and the origin is 3. However, we have two phases, 0 and 180 degrees.

b.

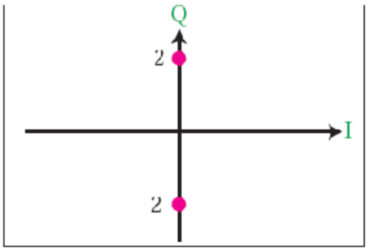


c. This can be either QPSK (one amplitude, four phases) or 4-QAM (one amplitude and four phases). The amplitude is the distance between a point and the origin, which is $(2^2 + 2^2)^{1/2} = 2.83$.



c.

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



d.

Q16. How many bits per baud can we send in each of the following cases if the signal constellation has one of the following number of points?

a. 2 b. 4 c. 16 d. 1024

Ans:

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. $\log_2 1024 = 10$

Q18. The telephone line has 4 KHz bandwidth. What is the maximum number of bits we can send using each of the following techniques? Let d = O.

a. ASK b. QPSK c. 16-QAM d.64-QAM

Ans:

We use the formula **$N = [1/(1 + d)] \times r \times B$**, but first we need to calculate the value of r for each case.
a. $r = \log_2 2 = 1 \rightarrow N = [1/(1 + 0)] \times 1 \times (4\text{ KHz})$ = **4 kbps**
b. $r = \log_2 4 = 2 \rightarrow N = [1/(1 + 0)] \times 2 \times (4\text{ KHz})$ = **8 kbps**
c. $r = \log_2 16 = 4 \rightarrow N = [1/(1 + 0)] \times 4 \times (4\text{ KHz})$ = **16 kbps**
d. r = $\log_2 64 = 6 \rightarrow N = [1/(1 + 0)] \times 6 \times (4\text{ KHz})$ = **24 kbps**

Q19. A corporation has a medium with a 1-MHz bandwidth (lowpass). The corporation needs to create 10 separate independent channels each capable of sending at least 10 Mbps. The company has decided to use QAM technology. What is the minimum number of bits per baud for each channel? What is the number of points in the constellation diagram for each channel? Let d =O.

Ans:

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.

Q20. A cable company uses one of the cable TV channels (with a bandwidth of 6 MHz) to provide digital communication for each resident. What is the available data rate for each resident if the company uses a 64-QAM technique?

Ans: We can use the formula: $N = [1/(1 + d)] \times r \times B = 1 \times 6 \times 6\text{ MHz} = 36\text{ Mbps}$