Chapter-5analogtransmission

Computer Engineering (Rizal Technological University)

CHAPTER 5
Analog Transmission

Review Questions

1. Define analog transmission.

Ans: Analog transmission means the transmission of analog signals using a band-pass channel. More specifically, Analogue data transmission consists of sending information over a physical transmission medium in the form of a wave.

2. Define carrier signal and its role in analog transmission.

Ans: A carrier signal is a single-frequency signals that has one of its characteristics like as amplitude, frequency, or phase. Its role in analog transmission is changed to represent the baseband signal.

3. Define digital-to-analog conversion.

Ans: Digital-to-analog conversion is the process of changing one of the characteristics of an analog signal based on the information in digital data. The baseband digital signal representing the digital data modulates the carrier to create a broadband analog signal.

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:

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

Ans: I think that, ASK is the most susceptible technique among the four digital-to-analog conversion techniques. Because of the amplitude is more affected by noise than the phase or frequency.

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 related to the in-phase carrier; the vertical Y axis is related to the quadrature carrier.

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.

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.

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: In analog to analog conversion,
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. Which of the three analog-to-analog conversion techniques (AM, FM, or PM) is the most susceptible to noise? Defend your answer.
Ans: I think that, AM, FM, PM, among this three analog to analog conversion techniques, the most susceptible technique is AM because the amplitude is more affected by noise than the phase or frequency.

Exercises

11. 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: For baud rate (S), we know that the formula is:

$$S = \frac{N}{r}$$

Here, N = Bit rate, which is given in each case.
r = number of elements, which is unknown. So, at first we need to calculate r for each case.
We know, $r = \log_2 L$.

a. For FSK, $r = \log_2 2 = 1$ ∴ $S = \frac{2000}{1}$ = 2000 baud

b. For ASK, $r = \log_2 2 = 1$ ∴ $S = \frac{4000}{1}$ = 4000 baud

c. For QPSK, $r = \log_2 4 = \log_2 2^2 = 2 \log_2 2 = 2$ ∴ $S = \frac{6000}{2}$ = 3000 baud

d. For 64-QAM, $r = \log_2 64 = \log_2 2^6 = 6 \log_2 2 = 6$ ∴ $S = \frac{36000}{6}$ = 6000 baud

12. 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: For baud rate (S), we know that the formula is:

$$S = \frac{N}{r}$$

∴ N = S * r

Here, N = Bit rate, which we find out in each case.
r = number of elements, which is unknown. So, at first we need to calculate r for each case.
We know, $r = \log_2 L$.

a. For FSK, $r = \log_2 2 = 1$ ∴ $N = 1000 * 1$ = 1000 bps

b. For ASK, $r = \log_2 2 = 1$ ∴ $N = 1000 * 1$ = 1000 bps

c. For BPSK, $r = \log_2 2 = 1$ ∴ $N = 1000 * 1$ = 1000 bps

d. For 16-QAM, $r = \log_2 16 = \log_2 2^4 = 4 \log_2 2 = 4$ ∴ $N = 1000 * 4$ = 4000 bps

13. 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: For the number of bits (r) per baud, we use the formula: $r = \log_2 L$

Here, L = type of the signal element, which is given in each case.

a. For ASK, $r = \log_2 4 = \log_2 2^2 = 2 \log_2 2 = 2$
b. For FSK, $r = \log_2 8 = \log_2 2^3 = 3 \log_2 2 = 3$
c. For PSK, $r = \log_2 4 = \log_2 2^2 = 2 \log_2 2 = 2$
d. For QAM, $r = \log_2 128 = \log_2 2^7 = 7 \log_2 2 = 7$

14. 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: Apologies, Later will solve.

15. 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: Apologies, Later will solve.

16. 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: For the number of bits (r) per baud, we use the formula: $r = \log_2 L$

Here, The number of points define the number of levels, (L) for each case.
a. $r = \log_2 2 = 1$
b. $r = \log_2 4 = \log_2 2^2 = 2\log_2 2 = 2$
c. $r = \log_2 16 = \log_2 2^4 = 4\log_2 2 = 4$
d. $r = \log_2 1024 = \log_2 2^{10} = 10\log_2 2 = 10$

17. What is the required bandwidth for the following cases if we need to send 4000 bps?
Let d = 1.
a. ASK
b. FSK with $2\Delta f = 4$ KHz
c. QPSK
d. 16-QAM.
Ans: Given, bit rate, N = 4000 bps
factor, d = 1

a. For ASK, r = 1 .'. Bandwidth, $B = (1+d)S = (1+d)\frac{N}{r} = (1+1)\frac{4000}{1} = 8000$ bps

b. For FSK, r = 1, .'. $B = (1+d)\frac{N}{r} + 2\Delta f = (1+1)\frac{4000}{1} + 4 * 10^3 = 12000$ bps

c. For QPSK, r = 2 .'. $B = (1+d)\frac{N}{r} = (1+1)\frac{4000}{2} = 4000$ bps

d. For 16-QAM, r = 4 .'. $B = (1+d)\frac{N}{r} = (1+1)\frac{4000}{4} = 2000$ bps

18. 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 = 0.
a. ASK
b. QPSK
c. 16-QAM
d.64-QAM.

Ans: We know the formula, $B=(1+d)\frac{N}{r}$.'. $N=\frac{B*r}{(1+d)}$

Given, B = 4 KHz; d = 0

a. r = 1 .'. $N=\frac{4*1}{(1+0)}$ = 4 kbps

b. r = 2 .'. $N=\frac{4*2}{(1+0)}$ = 8 kbps

c. r = 4 .'. $N=\frac{4*4}{(1+0)}$ = 16 kbps

d. r = 6 .'. $N=\frac{4*6}{(1+0)}$ = 24 kbps

19. 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: Given, umber of channel = 10

.'. Bit rate for each channel= $\frac{10\ Mbps}{10}$ = 1 Mbps

.'. bandwidth for each channel = $\frac{1\ MHz}{10}$ = 10^5 Hz. = 100 KHz

Now, We find the value of r for each channel:

$B=(1+d)\frac{N}{r}$ => $r=(1+d)\frac{N}{B}$ = $(1+0)\frac{1\ Mbps}{100\ KHz}$ = 10

.'. For the number of levels, we know formula: $r=\log_2 L$ => $L = 2^r$ = 2^{10} = 1024 This means that we need a 1024-QAM technique to achieve this data rate.

20. 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: Given Bandwidth, B = 6 MHz

For 64-QAM, $r = \log_2 64 = 6$

Now, we can use the formula: $B = (1+d)\frac{N}{r}$ => $N = \frac{B*r}{(1+d)}$ ¿ $\frac{6\,MHz*6}{(1+0)}$ = 36 Mbps

So, Data rate is 36 Mbps.

21. Find the bandwidth for the following situations if we need to modulate a 5-KHz voice.
a. AM
b. PM (set β =5)
c. PM (set β =1).

Ans: Given, FCC bandwidth, B = 5 KHz

a. AM Bandwidth formula, $B_{AM} = 2 \times B = 2 \times 5 = 10$ KHz
b. FM Bandwidth formula, $B_{FM} = 2(1+\beta)B = 2\times(1+5)\times5 = 60$ KHz
c. PM Bandwidth formula, $B_{PM} = 2(1+\beta)B = 2\times(1+1)\times5 = 20$ KHz

22. Find the total number of channels in the corresponding band allocated by FCC.
a. AM
b. FM

Ans:

a. According to FCC Bandwidth (5 KHz),
AM Bandwidth is 10 KHz per channel.
We know, carrier frequency of AM stations between 530 KHz to 1700 KHz
∴ Number of Channel, $n = \frac{1700-530}{10} = 117$

b. According to FCC, FM Bandwidth is 200 KHz per channel
We know, carrier frequency of FM stations between 88 MHz to 108 MHz
∴ Number of Channel, $n = \frac{(108-88)\,MHz}{200\,KHz} = \frac{20\,MHz}{200\,KHz} = 100$