Data Communications

Sample Questions

1- Delay can cause distortion is the shape of a signal. How can we relate this distortion to the data rate of the channel?
Higher data rates can be achieved through higher frequencies, larger bandwidth, and shorter bit period. As a result we have:
   - Using higher frequencies means that distortion rate due to the low pass filtering of the channel is more probable
   - Since in shorter bit period we need sharper bit boundaries, distortion due to the propagation delay of different harmonics will be higher.
   - Overlapping of a bit with its neighboring bit is more probable.

2- A channel with a bandwidth of 100kHz is using FDM. The channel is divided into 4 sub-channels where guard bands of 10 KHz exist between them. Assuming SNR=30, how much reduction will we have compared to the single channel case (No FDM case)?
We use 4 sub-channels separated with 3 guard bands of 10KHz each. Therefore each sub-channel has a bandwidth of
(Bandwidth of each sub-channel = (100-3*10)/4 = 17.5 KHz
From SNR = $10\log_{10}(S/N)$ we have
$30 = 10\log_{10}(S/N)$ ➔ S/N = 1000
Theoretical data rate (capacity) of each sub-channel = $17500\log_2(1+1000)$ =174430 bps

Therefore total data rate after dividing the channel is 4*174430 = 697710 bps

Without dividing the channel the data rate is
$C=100000\log(1+1001)= 996720$

The reduction in data rate is = 996720-697710=299010

3- What signal-to-noise ratio is needed to put a T1 carrier on a 150-kHz line?
The T1 carrier has a data rate of 1.544 Mbps
Assuming 1 Mb = 1000000 we have
$1544000 = 150000\log_2(1+S/N)$
S/N = 1253.9
SNR = $10\log_{10}(S/N) = 10\log_{10}(1253.9)= 30.9826$ dB

4- It is desired to send a set of short messages (10Kbytes) over a network. The sender receives 1000 messages from the applications in each minute. How much bandwidth is needed, if the communication channel is noise free and using 8 data levels? What if the channel is noisy with signal to noise ratio (SNR) of 20dB?
Required data rate = 1000*10,000*8*60 = $4.8 * 10^9$ bits/sec
Case 1: Noiseless channel

$4.8 * 10^9 = 2* W * \log2(8)$
$W = 800$ MHz
Case 2: Noisy channel
$SNR = 10\log_{10}(S/N) = 20 \rightarrow S/N = 100$
$4.8 * 10^9 = W * \log2(1+100)$
$W = 720.91$ MHz

5- A modem constellation diagram has data points at the following coordinates: (1, 1), (1, -1), (-1, 1), and (-1, -1). How many bps can a modem with these parameters achieve at 1200 baud?
4 symbols are used therefore each symbol carries 2 bits.
Bit rate = Baud rate * r ➔ 1200 * 2 = 2400

6- Consider the bit string 1001110100. Draw the encoding diagram for the following bit encoding methods:
   a. Manchester encoding
   b. Differential Manchester encoding
   c. NRZ
   d. NRZI

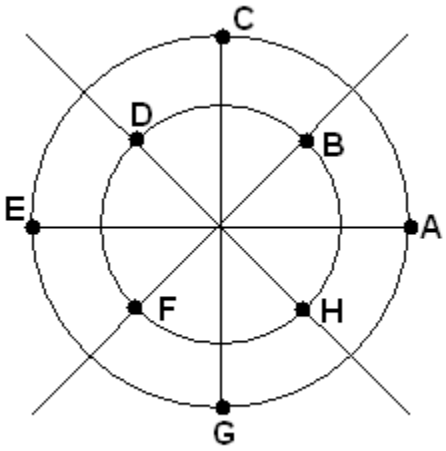
7- Assume a communication line has the bandwidth limit of 5000Hz. What should be the signal to noise ratio to reach a data rate of 20000 bps?
$20000 = 5000 * \log2(1+S/N)$
$S/N = 15$
$SNR = 10\log_{10}(15) = 11.761$ dB

8- A data network consists of two segments with attenuation rates of 10 and 12 dB respectively. To keep the data rate in the minimum required level we should limit the attenuation by adding an amplifier so that the signal energy does not drop more than %25. What should be the gain of the amplifier?
P2 should be >= 0.75 * P1
Assuming amplifier gain =X we have
$X – 12 – 10 = 10\log_{10}(0.75P1/P1) \rightarrow X >= 20.7506$

9- Maximum theoretic data rate in a noisy channel is 4000 bps. If the signal power is about 10 times more than the noise power:
   a. What is the bandwidth of the channel?
      $4000 = W * \log2(1+10) \rightarrow W = 1156$ Hz
   b. What is the Signal to Noise Ratio (SNR) of the channel?
      $SNR = 10\log_{10}(10) = 10$

10- The modulation diagram given below is used in a communication network
   a. How many bits per second are transmitted if the baud rate is 10000Hz
      We have 8 different points in the diagram. Therefore, each symbol transmits 3 bits (log2(8) = 3)
      Baud rate * r = bit rate
      10000 * 3 = 30000 bps
   b. Draw the wave form for the following data : 001000111101
      Create a table assigning bit patterns to each point and defining the amplitude and phase of each point.
      For example A = 000, Amplitude = High, Phase = 0

Then put the data in groups of 3 bits. For each group find the pattern and draw it.



11-A line has a signal-to-noise ratio (S/N) of 1000 and a bandwidth of 4000 KHz.

a. What is the maximum data rate supported by this line?
   C = 4000 * log2(1001) = 39869 bps
b. If ASK is used for modulation what is the maximum number of amplitude levels?
   L <= sqrt(1+S/N) ➔ sqrt(1001) = 31.6386
   The largest power of 2 less than 31.6386 is 16
c. What will be the bit-rate and baud-rate with the amplitude levels found in part b?
   Bit rate = $2*4000*\log_2(16) = 32000$ bps
   Baud rate = $32000/\log_2(16) = 8000$

12-We measure the performance of a telephone line (4 KHz of bandwidth). When the signal is 10 W, the noise is 5 mW.

a. What is the maximum data rate supported by this telephone line?
   C = 4000 log2(1 + 2000) = 43866 bps
b. What is the maximum data rate if the attenuation of the line is 5dB?
   With 5dB attenuation, the signal is delivered with a power of P2 which is
   $-5 = 10\log_{10}(P2/P1)$
   P2 = P1/ 3.1623 ➔ signal power = 10/ 3.1623 = 3.1623 W
   C = 4000 log2(1 + 3162.3/5) = 37228 bps

13-What is the length of a bit in a channel with a propagation speed of 2×10^8 m/s if the channel uses QAM8 (Quadrature Amplitude Modulation with 8 signaling elements) and the bandwidth is

a. 1 MHz?
   Data rate = 2*1,000,000 * log2(8) = 6,000,000 bps
   6,000,000 bits will occupy 2×10^8 meters so each bit will be 133.3334 meters
b. 10 MHz?
   Data rate = 2*10,000,000 * log2(8) = 60,000,000 bps

60,000,000 bits will occupy 2 x 108 meters so each bit will be 13.33334 meters

14- Explain how skin effect reduces the data rate in a channel.

In high frequencies, the electrons escape the center and concentrate over the outer surface (skin) of the wire. This means the effective cross sectional area of the wire is reduced which in turn increases the resistance of the wire.