# Computer Networks (CS30006)
## Question Bank 1
## Solutions

1. A periodic signal has a bandwidth of 20 Hz. The highest frequency is 60 Hz. What is the lowest frequency?

   **Solution**:
   Let $f_h$ be the highest frequency, $f_l$ the lowest frequency, and B the bandwidth. Then
   $B = fh - f_l$
   $20 = 60 - f_l$
   $f_l = 60 - 20 = 40$ Hz

2. A digitized voice channel, is made by digitizing a 4-kHz bandwidth analog voice signal. We need to sample the signal at twice the highest frequency (two samples per hertz). We assume that each sample requires 8 bits. What is the required bit rate?

   **Solution:**
   The bit rate can be calculated as
   2 x 4000 x 8 =64,000 bps =64 kbps

3. The loss in a cable is usually defined in decibels per kilometer (dB/km). If the signal at the beginning of a cable with -0.3 dBlkm has a power of 2 mW, what is the power of the signal at 5 km?

   **Solution**
   The loss in the cable in decibels is $5 \times (-0.3) = -1.5$ dB. We can calculate the power as

$$\mathrm{dB} = 10 \log_{10} \frac{P_2}{P_1} = -1.5$$

$$\frac{P_2}{P_1} = 10^{-0.15} = 0.71$$

$$P_2 = 0.71 P_1 = 0.7 \times 2 = 1.4 \text{ mW}$$

4. We have a channel with a 1 MHz bandwidth. The SNR for this channel is 63. What are the appropriate bit rate and signal level?

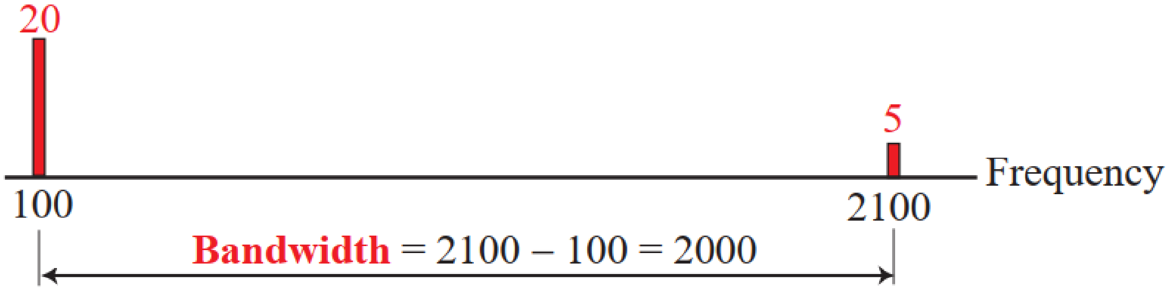
   **Solution**:
   First, we use the Shannon formula to find the upper limit.
   C =B log2 (l + SNR) = $10^6$ $\log_2$ (1 + 63) = $10^6$ $\log_2$ 64 =6 Mbps
   The Shannon formula gives us 6 Mbps, the upper limit. For better performance we choose something lower, 4 Mbps, for example. Then we use the Nyquist formula to find the number of signal levels.
   4Mbps=2x 1 MHz x $\log_2$ L
   L=4

5. A network with bandwidth of 10 Mbps can pass only an average of 12,000 frames per minute with each frame carrying an average of 10,000 bits. What is the throughput of this network?

   **Solution**:
   We can calculate the throughput as
   Throughput= 12,000 x 10,000/60 =2 Mbps

6. A periodic composite signal with a bandwidth of 2000 Hz is composed of two sine waves. The first one has a frequency of 100 Hz with a maximum amplitude of 20 V; the second one has a maximum amplitude of 5 V. What is the bandwidth?

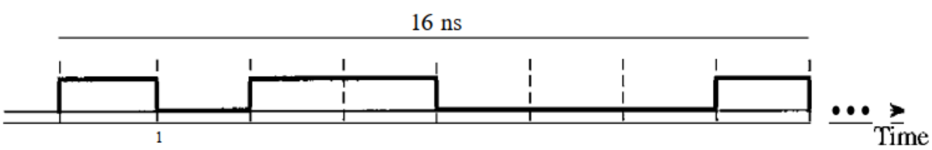
   **Solution**
   We know the bandwidth is 2000. The highest frequency must be 100 + 2000 = 2100 Hz.



7. A device is sending out data at the rate of 1000 bps.
   a. How long does it take to send out 10 bits?
   b. How long does it take to send out a single character (8 bits)?
   c. How long does it take to send a file of 100,000 characters?

   **Solution:**
   **a.** (10 / 1000) s = 0.01 s
   **b.** (8 / 1000) s = 0. 008 s = 8 ms
   **c.** ((100,000 × 8) / 1000) s = 800 s

8. What is the bit rate for the signal in Figure?




**Solution:**
There are 8 bits in 16 ns. Bit rate is 8 / ($16 \times 10^{-9}$) = $0.5 \times 10^{9}$ = 500 Mbps

9. The attenuation of a signal is -10 dB. What is the final signal power if it was originally 5 W?

**Solution:**
We have dB = log10 (P2/P1).
– 10 = 10 log10 (P2 / 5)
log10 (P2 / 5) = -1
(P2 / 5) = $10^{-1}$
P2 = 0.5 W

10. A line has a signal-to-noise ratio of 1000 and a bandwidth of 4000 KHz. What is the maximum data rate supported by this line?

**Solution:**
We use the Shannon capacity C = B $\log_2$ (1 + SNR)
C = 4,000 $\log_2$ (1 + 1,000) ≈ 40 Kbps

11. We measure the performance of a telephone line (4 KHz of bandwidth). When the signal is 10 V, the noise is 5 mV. What is the maximum data rate supported by this telephone line?

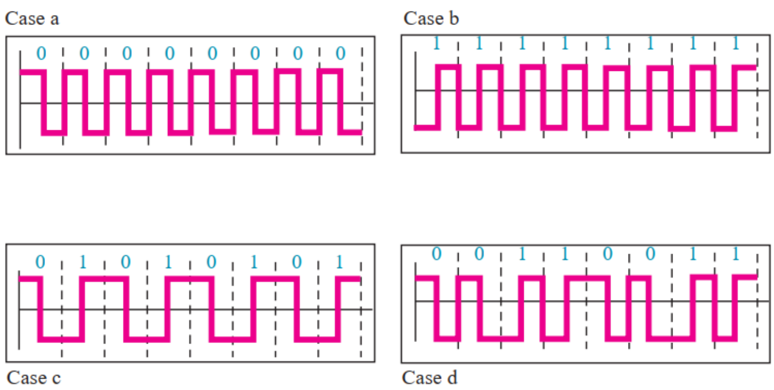
**Solution:**
SNR is the ratio of the powers. The power is proportion to the voltage square ($P = V^2/R$). Therefore, we have $SNR = (10)^2 / (10 \times 10^{-3})^2 = 10^6$. We then use the Shannon capacity to calculate the maximum data rate.
$C = 4{,}000 \log_2 (1 + 10^6) \approx 80$ Kbps

12. What is the transmission time of a packet sent by a station if the length of the packet is 1 million bytes and the bandwidth of the channel is 200 Kbps?

**Solution:**
We have transmission time = (packet length in bits)/(bandwidth) = (8,000,000 bits) / (200,000 bps) = 40 s

13. Draw the graph of the Manchester scheme using each of the following data streams, assuming that the last signa11evel has been positive.

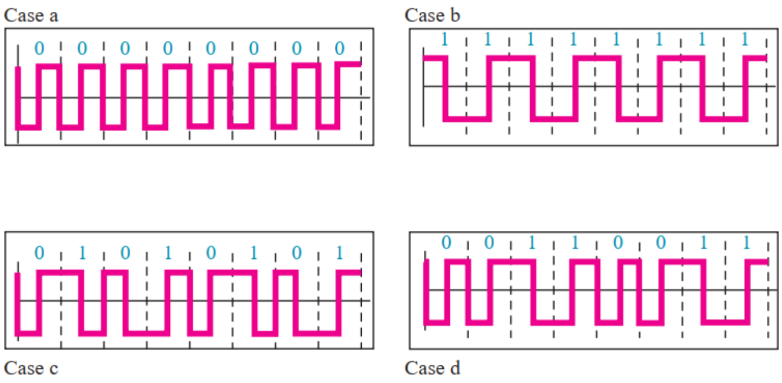
**a.** 00000000
**b.** 11111111
**c.** 01010101
**d.** 0011001




14. Draw the graph of the Differential Manchester scheme using each of the following data streams, assuming that the last signa11evel has been positive.

**a.** 00000000
**b.** 11111111
**c.** 01010101

**d.** 0011001




15. 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

   **Solutions:**
   We use the formula S = (1/*r*) × N, but first we need to calculate the value of r for each case.
   **a.** $r = \log_2 2 = 1 \rightarrow S = (1/1) \times (2000 \text{ bps}) = 2000$ 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

16. For binary phase-shift keying, *Eb*/*N*0 = 8.4 dB is required for a bit error rate of 10-4 (1 bit error out of every 10,000). If the effective noise temperature is 290 K (room temperature) and the data rate is 2400 bps, what received signal level is required?
   **Solution:**
   We have
   8.4 = *S*1dBW2 - 10 log 2400 + 228.6 dBW - 10 log 290
   = *S*1dBW2 - 110213.382 + 228.6 - 110212.462
   *S* = -161.8 dBW

17. Given the narrow (usable) audio bandwidth of a telephone transmission facility, a nominal SNR of 56 dB (400,000), and a certain level of distortion
   **a.** What is the theoretical maximum channel capacity (kbps) of traditional telephone lines?
   **b.** What can we say about the actual maximum channel capacity?

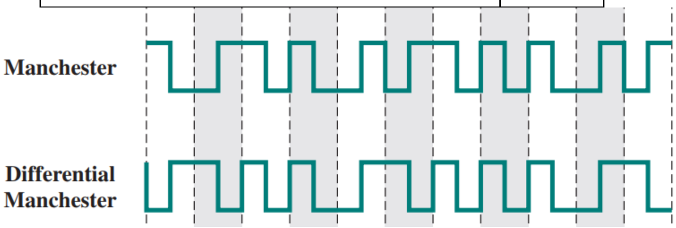
**Solution:**

(a.) Using Shannon’s formula: C = 3000 $\log_2(1+400000)$ = 56 Kbps
(b.) Due to the fact there is a distortion level (as well as other potentially detrimental impacts to the rated capacity, the actual maximum will be somewhat degraded from the theoretical maximum.

18. For the 11-bit binary string 01001100011, what are the number of transitions for the encoding scheme: a) Manchester b) Differential Manchester

**Solution:**

| | |
|---|---|
| Manchester | 16 |
| Differential Manchester | 16 |




19. Suppose there is exactly one packet switch between a sending host and a receiving host. The transmission rates between the sending host and the switch and between the switch and the receiving host are $R1$ and $R2$, respectively. Assuming that the switch uses store-and-forward packet switching, what is the total end-to-end delay to send a packet of length $L$? (Ignore queuing, propagation delay, and processing delay.)

**Solution:**

At time $t_0$ the sending host begins to transmit. At time $t_1 = L/R_1$, the sending host completes transmission and the entire packet is received at the router (no propagation delay). Because the router has the entire packet at time $t_1$, it can begin to transmit the packet to the receiving host at time $t_1$. At time $t_2 = t_1 + L/R_2$, the router completes transmission and the entire packet is received at the receiving host (again, no propagation delay). Thus, the end-to-end delay is $L/R_1 + L/R_2$.

20. How long does it take a packet of length 1,000 bytes to propagate over a link of distance 2,500 km, propagation speed 2.5 · 108 m/s, and transmission rate 2 Mbps? More generally, how long does it take a packet of length $L$ to propagate over a link of distance $d$, propagation speed $s$, and transmission rate $R$ bps? Does this delay depend on packet length? Does this delay depend on transmission rate?

**Solution:**
10msec; d/s; no; no