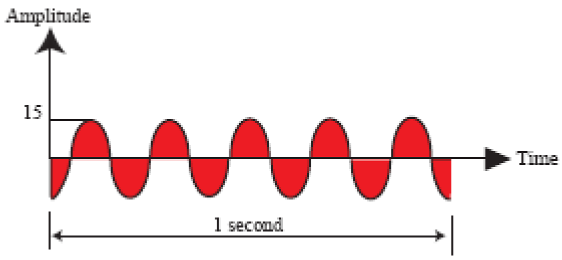
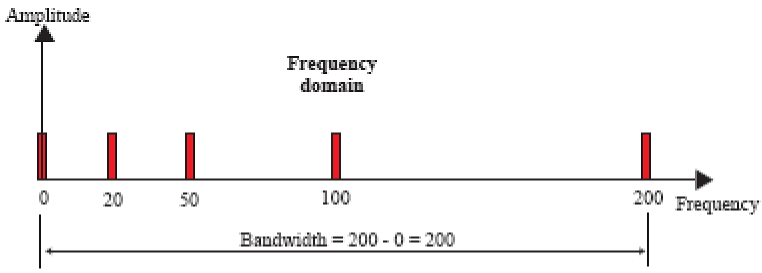
Subject :	**SEHH2238 : Computer Networking**
Lab/Tutorial :	**Session 2 : Signal Transmission (Solution)**

1) Time and Frequency Domain

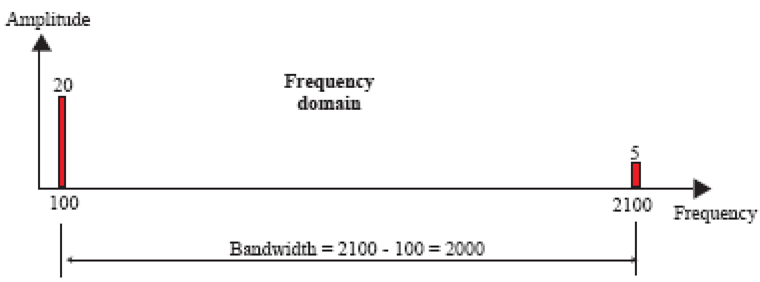
1) Draw the time-domain plot of a sine wave (for only 1s) with maximum amplitude of 15V, frequency of 5 and phase 270^o.



2) What is the bandwidth of a signal that can be decomposed into four sine waves with frequencies at 0, 20, 50, 100 and 200 Hz? All maximum amplitudes are the same. Draw the frequency spectrum.



3) 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 20V; the second one has a maximum amplitude of 5 V. Draw the frequency spectrum.



2) Transmission Impairment

1) 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 dB/km has a power of 2 mW, what is the power of the signal at 5 km?

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

$$\boxed{\begin{gathered} \text{dB} = 10 \log_{10} \frac{P_2}{P_1} = -1.5 \\ \frac{P_2}{P_1} = 10^{-0.15} = 0.71 \\ P_2 = 0.71 P_1 = 0.7 \times 2 = 1.4 \text{ mW} \end{gathered}}$$

2) If the power of a signal is 0.5W and the power of the noise is 10mW. What is the SNR? What is SNRdB?

   $SNR = 0.5 / (10 \times 10^{-3}) = 50$
   $SNR_{dB} = 10 \log_{10} 50 = 16.99$

3) Data Rate

1) We need to send data at a rate 265 kbps over a noiseless channel with a bandwidth of 20 kHz. How many signal levels do we need?

$$\begin{aligned} \text{Bit Rate} &= 2 \times B \times \log_2 L \quad \text{(by Nyquist Bit Rate)} \\ 265 \times 10^3 &= 2 \times 20 \times 10^3 \times \log_2 L \\ \log_2 L &= 6.625 \\ L &= 98.7 \end{aligned}$$

2) A measurement is done on a telephone line (4kHz of bandwidth). When the signal is 10W, the noise is 5mW. What is the maximum data rate supported by this telephone line?

$$\begin{aligned} \text{Max. Bit Rate} &= B \times \log_2(1 + SNR) \quad \text{(by Shannon Capacity)} \\ &= 4000 \times \log_2(1 + 10 / (5 \times 10^{-3})) \\ &= 4000 \times 11 \\ &= 44\text{Kbps} \end{aligned}$$

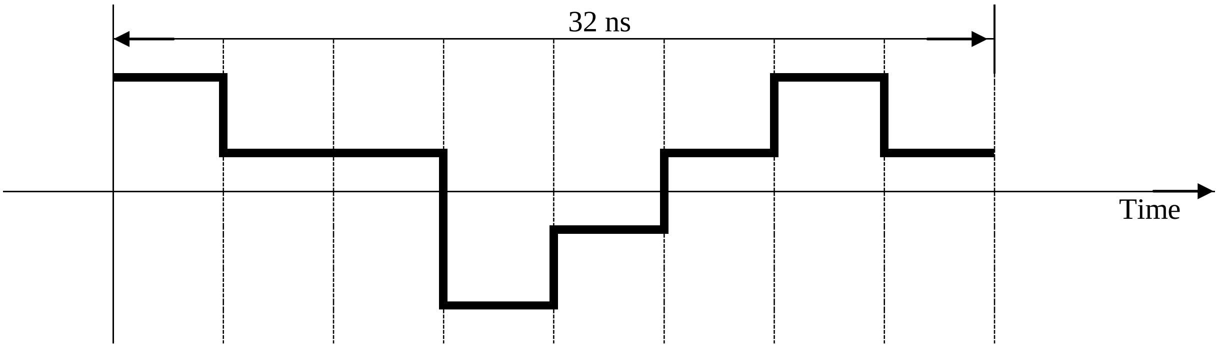
3) We have a channel with a 1-MHz bandwidth. The SNR for this channel is 63. What are the appropriate bit rate and signal level?

$$\begin{aligned} \text{Max. Bit Rate} &= B \times \log_2(1 + SNR) \quad \text{(by Shannon Capacity)} \\ &= 1 \times 10^6 \times \log_2(1 + 63) \\ &= 6 \times 10^6 \\ &= 6\text{Mbps} \end{aligned}$$

   Hence, 6 Mbps is the upper limit of bit rate in this noisy channel. For better performance, we choose something lower, says 4 Mbps. Since noise has been considered, we can use Nyquist formula to determine the number of signal levels.

$$\begin{aligned} \text{Bit Rate} &= 2 \times B \times \log_2 L \quad \text{(by Nyquist Bit Rate)} \\ 4 \times 10^6 &= 2 \times 1 \times 10^6 \times \log_2 L \\ L &= 4 \end{aligned}$$

4) What is the bit rate for signal in the following figure?



Duration of one signal = 32 ns / 8 = 4 ns
One signal carries $\log_2 4$ = 2 bits
Bit rate = No. of bits per signal / Duration of one signal
= 2 / (4 x 10^{-9}) = 5 x 10^{8} = 500 Mbps