Tutorial 9 Solutions

Instructions

1. Form ad-hoc groups of 2 to 3 students to solve this week's exercise.
2. Each group must answer the following review Q's
3. Each group will use shared google docs to work with all group members and tutor. The document must include the group members' names and the tutorial sheet number.

Review Questions

1. Q7-1. How can we find the period of a sine wave when its frequency is given?

   Answer: The period of a signal is the inverse of its frequency: T = 1/f.

2. Q7-5. Which of the following are causes of transmission impairment?

   a) Attenuation
   b) modulation
   c) noise

   Answer: Attenuation and noise are two out of three causes of transmission impairment; distortion is the third one.

3. Q7-9. Define baseband transmission?

   Answer: Baseband transmission means sending a digital or an analog signal without modulation using a low-pass channel.

4. Q7-11. Define the theoretical maximum channel capacity bit rate of a noiseless channel using Nyquist theorem and Shannon's theorem for noisy channel?

   Answer: The Nyquist theorem defines the maximum bit rate of a noiseless channel.

   A very important consideration in data communications is how fast we can send data called capacity in bits per second, over a channel. Data rate depends on three factors:

   - *The bandwidth available*
   - *The levels of the signals we use*
   - *The quality of the channel (the level of noise)*

   Two theoretical formulas were developed to calculate the data Capacity:

   1. *Nyquist for a noiseless channel(Nyquist Equation)*

      $$C = 2\,B\,\log_2 L$$

   2. *Shannon for a noisy channel (Shannon's Equation)*

      $$C = B\,\log_2 (1 + SNR)$$

      Where:
      C = Capacity of the channel in bps

B = Bandwidth of the channel in Hz
L = Number of voltage levels in digital signal
SNR = Signal to noise ratio

5. Differentiate between guided media and unguided media?

Answer: *With guided media, the electromagnetic waves are guided along an enclosed physical path whereas unguided media provide a means for transmitting electromagnetic waves but do not guide them.*

6. Define channel capacity?

Answer: The rate at which data can be transmitted over a given communication path, or channel, under given conditions, is referred to as the channel capacity.

7. Q7-19. Which characteristics of an analog signal are changed to represent the analog signal in each of the following analog-to-analog conversions?

   a. FM
   b. PM

Answer*:* *a. FM changes the frequency of the carrier.*

b. PM changes the phase of the carrier.

8. Q7-23. Define synchronous TDM and compare it with statistical TDM.

Answer*:*

*In **synchronous TDM**, each input has a reserved slot in the output frame. This can be inefficient if some input lines have no data to send.*

*In **statistical TDM**, slots are dynamically allocated to improve bandwidth efficiency.*

9. Q7-27. What are the **three** major classes of guided media?

Answer*: The three major categories of guided media are twisted-pair, coaxial, and fiber-optic cables.*

10. P7-15. A signal has passed through three cascaded amplifiers, each with a 4 dB gain. What is the total gain? How much is the signal amplified?

*Answer: The total gain is 3 * 4 = 12dB. To find how much the signal is amplified, we can use the following formula:*

$12 = 10 \log (P_2 / P_1)$
$\text{So, } \log_{10} (P_2 / P_1) = 1.2$
$\text{Thus, } P_2 / P_1 = 10^{1.2} = 15.85$

The signal is amplified almost 16 times.

11. P7-19. We measure the performance of a telephone line (4kHz of bandwidth). When the signal is 10V, the noise is 10 mV. What is the maximum data rate supported by this telephone line?

Answer: SNR is the ratio of powers. The power is proportional 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.
$C = 4000 \log_2 (1+10^6) = 80$ Kbps

12. P7-35. We have sampled a low-pass signal with a bandwidth of 200 kHz using l024 levels of quantization.
a. Calculate the bit rate of the digitized signal.
b. Calculate the SNR for this signal.
c. Calculate the PCM bandwidth of this signal.

Answer:
a.
$f_{max} = 0 + 200 = 200$ kHz.
So, $f_s = 2 * 200{,}000 = 400{,}000$ samples/s
$n_b = \log_2 1024 = 10$ bits/sample.
So, $n = 400{,}000 * 10 = 4$ Mbps
b.
$SNR_{dB} = 6.02\ n_b + 1.76 = 61.96$
c.
$B_{PCM} = (n_b) * (B_{analog}) = 10 * 200$ kHz $= 2$ MHz

13. P7-59.An copper Shielded Twisted Pair cable has a loss of 1 dB per Km at 10 kHz. We want to have a link of 10 Km using this cable. What should the power of the signal be at the source if we want the signal to have 10 mW power at the destination?

Answer:

The loss of the cable for 10Km is $10_{dB} = 10 \log_{10} (P_2/P_1)$.

This means, $\log_{10} (P_2/P_1) = -1$, or

$(P_2/P_1) = 1/10$, resulting in $P_1 = 10 * P_2 = 100$ mW.

14. A digital signalling system is required to operate at 1200 bps. If a signal element encodes a 4-bit word, what is the minimum required bandwidth of the channel?

Answer:
Using Nyquist's equation: $C = 2B \log_2 M$
We have $C = 12000$ bps
$\log_2 M = 4$, because a signal element encodes a 4-bit word

Therefore, $C = 12000 = 2B \times 4$, and $B = 1500$ Hz