Q(1) We measure the performance of a telephone line (4KHz of bandwidth). When the signal is 20V, the noise is 6mV. What is the maximum data rate supported by this telephone line?

Soln: Since, we know that channel capacity is given by

$$\text{Capacity} = \text{Bandwidth} \times \log_2(1+SNR)$$

Bandwidth of telephone line $= 4KHz = 4 \times 10^3 Hz$

Signal is 20V

Noise is 6mV

$\therefore$ Signal to Noise ratio is $(SNR) = \dfrac{20}{6 \times 10^{-3}} = 3333.33$

$\therefore$ SNR can be approximated to

$$SNR = 3333$$

$\therefore$ Capacity is given by

$$\text{Capacity} = 4 \times 10^3 \times \log_2(1+3333)$$

$$= 4 \times 10^3 \times 11.70303839$$

$$= 46812.15356 \text{ bps}$$

Hence, capacity can be approximated to

Capacity $= 46812$ bps. $=$ ~~46681~~ 46.812 Kbps.

(Q2). Calculate the time period when the frequency of the signal is 10MHz ?

Soln: frequency = $\frac{1}{\text{timeperiod}}$

$\therefore$ Time period = $\frac{1}{\text{frequency}}$

$= \frac{1}{10 \times 10^{6}}$ secs

Timeperiod = 10^{-7} secs

(Q3) A device is transmitting data at a rate of 2000bpsecs, Calculate the time taken for the device to send out 100 bits?

Soln: The data rate is 2000bps

$\therefore$ Bits interval is the time taken for a bit.

$\therefore$ Bit interval = $\frac{1}{\text{data rate}}$

$= \frac{1}{2000}$

$= 5 \times 10^{-4}$ secs.

$\therefore$ Total time taken to send 100 bits is Bit interval $\times$ no of bits

$= 5 \times 10^{-4} \times 100 = 0.05$ secs.

(Q4). A line has a SNR of 2000 and a bandwidth of 5000KHz. What is the maximum data rate supported by this line?

Soln: The maximum data rate can be calculated from the channel capacity calculated by shannon's capacity.

$$\text{capacity} = \text{Bandwidth} \times \log_2(1+SNR)$$

$$= 2000 \times \log_2(2000+1)$$

$$= 2000 \times 10.96650545$$

$$= 21933.0109 \text{ bps}$$

$$\simeq 21933 \text{ bps} = 21.933 \text{ Kbps.}$$

(Q5). We have a channel with 5KHz bandwidth. If we want to send data at 150Kbps, what is the minimum SNRdB? what is SNR?

Soln: We know that the capacity is given by

$$\text{Capacity} = \text{Bandwidth} \times \cancel{(1+SNR)} \log_2(1+SNR)$$

$$\log_2(1+SNR) = \frac{\text{Capacity}}{\text{Bandwidth}}$$

$$\log_2(1+SNR) = \frac{150000}{5000} = 30$$

$$\log_2(1+SNR) = 30$$

$$\therefore 2^{30} = 1+SNR \quad \left\{ \begin{array}{l} \text{ex } \log_2 16 = 4 \\ \therefore 2^4 = 16 \end{array} \right\}$$

$$1073741824 = 1+SNR$$

$$\therefore SNR = 1073741823$$

$$SNR_{dB} = 10 \log_{10} SNR$$

$$SNR_{dB} = 90.3089987$$

(Q5) A signal with 300 milliwatts power passes through 10 devices, each with an average noise of 3 microwatt. What is SNR? What is SNR_{dB}?

Q & A

Year - 2009

Q (9) (e) Suppose that the frame size is 1024 bits, and bit error rate is 10^{-4}. A source transmits 10 frames to a destination. What is the probability that all the frames will reach the destination without errors?

Soln:

P_b = probability that a bit is received in error, known as Bit Error rate (BER).

P_1 = Probability that a frame arrives with no bit error.

P_2 : probability that, with an error detecting algorithm in use, a frame arrives with one or more undetected errors.

$P_1 = (1 - P_b)^F$ where F is the number of bits per frame.

$P_2 = 1 - P_1$

$P_1 = (1 - P_b)^F$

$P_1 = (1 - 10^{-4})^{1024}$ $\left\{ \begin{array}{l} P_b = 10^{-4} \text{ (BER)} \\ F = 1024 \end{array} \right\}$