KFUPM - COMPUTER ENGINEERING DEPARTMENT

COE-540 – Computer Networks

Student Name:
Student Number:

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a) A = 1 volts, T = 1 msec ➔ f0 = 1/T = 1000 Hz.

From textbook/slides/notes, the coefficients are given by:

$$a_n = \frac{A}{\pi n}[\cos(\pi n/4) - \cos(3\pi n/4) + \cos(6\pi n/4) - \cos(7\pi n/4)]$$
$$b_n = \frac{A}{\pi n}[\sin(3\pi n/4) - \sin(\pi n/4) + \sin(7\pi n/4) - \sin(6\pi n/4)]$$
$$c = 3A/4$$

Then the output signal is given by

$$g_{LPF}(t) = c/2 + a_1 \sin\left(\frac{2\pi \times 1}{T}t\right) + a_2 \sin\left(\frac{2\pi \times 2}{T}t\right) + a_3 \sin\left(\frac{2\pi \times 3}{T}t\right) + b_1 \cos\left(\frac{2\pi \times 1}{T}t\right) + b_2 \cos\left(\frac{2\pi \times 2}{T}t\right) + b_3 \cos\left(\frac{2\pi \times 3}{T}t\right)$$

The power for $g_{LPF}(t)$ is simply equal to:

$$P_{g_{LPF}(t)} = \left(\frac{c}{2}\right)^2 + \sum_{n=1}^{3} \frac{a_n^2}{2} + \frac{b_n^2}{2}$$

Substituting, power is output signal is

b) The noise power for this system is given by

$$N = N_0 \times B = 1.0539 \times 10^{-16} \times 3000 = 3.1617 \times 10^{-13} \text{ Watts}$$

The bandwidth for the system B is equal to $3 \times f_0 = 3000$ Hz.

Therefore, SNR is given by

$$SNR = \frac{avg\ signal\ power}{avg\ noise\ power} = \frac{P_{g_{LPF}(t)}}{N_0 \times B} = \frac{0.3162 \times 10^{-6}}{3.1617 \times 10^{-13}} \sim 1000 \text{ or } 60 \text{ dB}$$

c) The maximum theoretical capacity is given by Shannon formula:

$$C = B \times \log_2(1 + SNR)$$
$$= (3000) \times \log_2(1 + 1000)$$
$$\sim 59.8\ kb/s$$

d) Ignoring noise, C = 2B log2(M) – we can choose M as large as possible ➔ C can be as large as possible.

e) To achieve C = 59.8 kb/s using a bandwidth of 3000 Hz

C = 2B log2(M) → M = ceil(2^ (C/2B)) = 10001 symbols

This is typically rounded up to the nearest power of 2 – Ans = 1024 symbols.