SINGAPORE POLYTECHNIC **ET0930**

Section B

B1. (a) Sketch the block diagram of a digital communication system. Label each block clearly. (6 marks)

(b) State two advantages and two disadvantages of digital communication over analog communication. (4 marks)

(c) Briefly explain the purpose of source coding and channel coding. (4 marks)

Source coding converts a symbol sequence into an efficient binary sequence by assigning a codeword to each symbol, during which redundant information is removed.

Channel encoding converts the source encoded binary sequence into a form that will allow the receiver to decode with reduced errors, which is accomplished by systematically adding extra bits to the output of the source encoder.

B2. (a) Define periodic and non-periodic signals. Give one example for each. (4 marks)

Periodic signals are signals that repeat their waveforms.
One example: cosine wave/sine wave/rectangular wave.

Non-periodic signals are signals that do not repeat their waveforms.
One example: speech/music signal

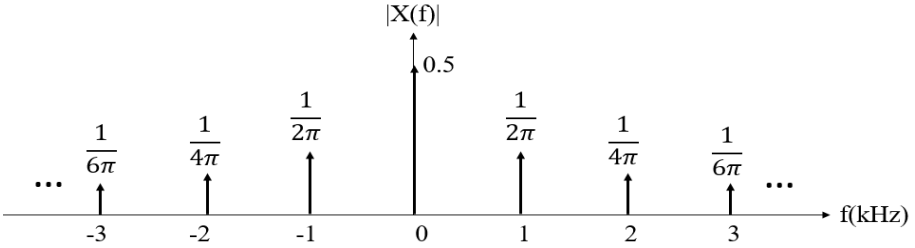
(b) The Fourier series of a signal is given by

$$v(t) = \frac{1}{2} - \frac{1}{\pi}\sin 2000\pi t - \frac{1}{2\pi}\sin 4000\pi t - \frac{1}{3\pi}\sin 6000\pi t - \frac{1}{4\pi}\sin 8000\pi t - \ldots$$

(i) Determine frequency and the peak voltage of the fundamental frequency component. (2 marks)

fundamental frequency = 1 kHz
peak voltage of the fundamental component = $1/\pi$ =0.32 volt

(ii) Sketch the double-sided amplitude spectrum of the signal up to the 3th harmonic showing the frequency of each component and its peak amplitude. (8 marks)



B3. (a) Determine the power and the RMS voltage of the thermal noise produced by a 1kΩ resistor over a bandwidth of 15 kHz. The temperature of the resistor is 25°C. (4 marks)

$T = 273 + 25 = 298K$

$P_n = kTB = 1.38\times10^{-23} \times 298 \times 15 \times 10^3 = 6.17\times10^{-17}$ W

$E_n = \sqrt{4kTBR} = \sqrt{4P_nR} = \sqrt{4 \times 6.17 \times 10^{-17} \times 10^3} = 4.97 \times 10^{-7}$V

(b) State the effect on thermal noise power:

(i) If the bandwidth is reduced. (2 marks)

If the bandwidth is reduced, thermal noise power is reduced.

(ii) If the resistance value is reduced. (2 marks)

If the resistance value is reduced, thermal noise power remains unchanged.

(c) The input signal and noise power of the amplifier shown in Figure B3 are 2mW and 0.1mW, respectively. The amplifier has a power gain(G) of 10 and a noise factor(F) of 1.5. Given that $N_1 = kT_oB$, determine the SNR at the output of the amplifier. (4 marks)

$$SNR_i = \frac{2mW}{0.1mW} = 20$$

$$F = \frac{SNR_i}{SNR_o} = 1.5$$

$$SNR_o = \frac{SNR_i}{F} = 13.33$$

(d) What is SNR used for? (2 marks)

SNR is used to determine how noisy a signal is.

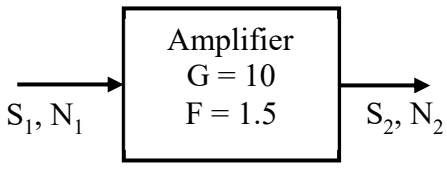


Figure B3

B4. (a) It is required to transmit a range of frequencies from 65 MHz to 95 MHz using a single antenna. What should be the minimum length of the antenna for efficient transmission of these signals? (4 marks)

$\lambda_{64\ MHz} = 3\times10^8/(65\times10^6) = 4.62$ m

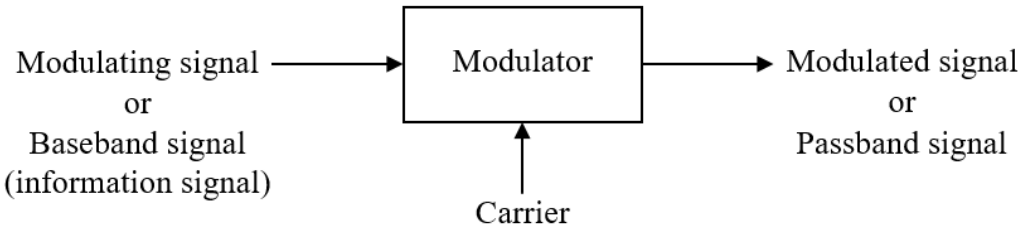
$\lambda_{84\ MHz} = 3\times10^8/(95\times10^6) = 3.16$ m

Minimum antenna length = $0.1\ \lambda_{64\ MHz} = 0.1 \times 4.62 = 0.462$ m

(b) Draw and label a diagram of a AM modulator. Briefly explain the following terms:

(i) Modulating signal
(ii) Modulation
(iii) Carrier
(iv) Modulated signal

(7 marks)



(i) The baseband signal (information signal) that we want to send at the input of the modulator is known as **modulating signal**.

(ii) The process of impressing a baseband signal (information signal) onto a high frequency sinusoid is known as **modulation**.

(iii) The high frequency sinusoid is known as **carrier signal** or **carrier**.

(iv) The high frequency modulated signal at the output of the modulator is known as **modulated signal**.

(c) If the modulating signal has a bandwidth of 8 kHz, what is the bandwidth of the AM and DSBSC signals? (3 marks)

Bandwidth of AM signal = $2f_s$ = 16 kHz

Bandwidth of DSBSC = Bandwidth of AM signal = 16 kHz

B5. The waveform of an AM signal is shown in Figure B5.

(a) Determine the frequency of the carrier and the modulating signal. (2 marks)

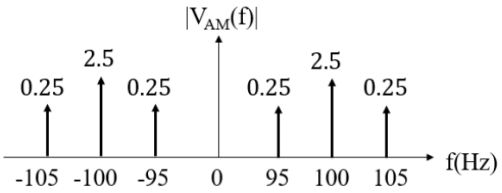
$f_s = 5$ kHz $f_c = 100$ kHz

(b) Write the equation for the AM signal. (6 marks)

$Env_{max} = 6$ V, $Env_{min} = 4$ V

$v_{AM}(t) = [V_c + V_s\cos 2\pi f_s t]\cos 2\pi f_c t = [5 + \cos(10\pi \times 10^3 t)]\cos 2\pi \times 10^5 t$

(c) Draw double-sided amplitude spectrum of AM signal. (6 marks)



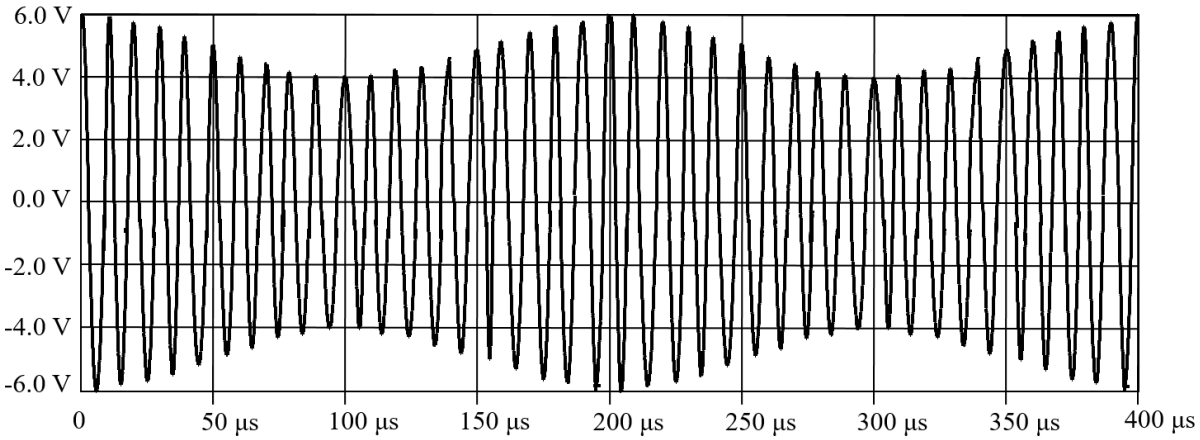


Figure B5

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