The Open University of Sri Lanka
Department of Electrical and Computer Engineering
Final Examination 2009/2010
ECX5233 – Radio and Line Communication

Time: 1400 – 1700 hrs. Date: 2011-03 -25

Answer any FIVE questions

1.

(a) The Carrier signal $x(t) = A\cos\omega_c t$ is amplitude modulated using a base-band signal $m(t)$.

(i) Write an expression for the modulated carrier $y(t)$. [2 *marks*]

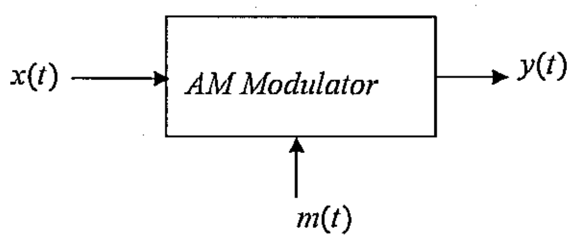


Fig.1

(ii) If $m(t) = kB\sin\omega_m t$ derive an expression for the percentage power in the side lobes. [3 *marks*]

(iii) If $m(t)$ is any periodic signal write an expression for $Y(\omega)$ in terms of $M(\omega)$. ($Y(\omega)$ and $M(\omega)$ are the *Fourier Transforms* of $y(t)$ and $m(t)$ respectively). [3 *marks*]

(A, B and k are constants)

(b) A frequency modulated carrier is given by $x_c(t) = \cos(\omega_c t + \beta\sin\omega_m t)$, where ω_m is the modulating frequency and β is a constant.

(i) Show that $X_c(\omega)$ can be written in the form

$$X_c(\omega) = \delta(\omega-\omega_c) + k\left[\delta(\omega-\omega_c-\omega_m) - \delta(\omega-\omega_c+\omega_m)\right] + \delta(\omega+\omega_c) + k\left[\delta(\omega+\omega_c+\omega_m) - \delta(\omega+\omega_c-\omega_m)\right] \quad \text{if } \beta << 1$$

[8 *marks*]

(k is a constant)

(ii) Write an expression for the instantaneous frequency of $x_c(t)$ and hence find the maximum frequency deviation of the carrier Δf. [4 *marks*]

2.

(a) Define the convolution of the function $x(t)$ with the function $y(t)$ $[x(t) * y(t)]$. [2 *marks*]

(b) If $x(t) = p(t)$ and $y(t) = \delta(t - T)$ sketch $x(t) * y(t)$, where $p(t)$ is the rectangular pulse shown in Fig.2(a) and T is a constant. [3 *marks*]

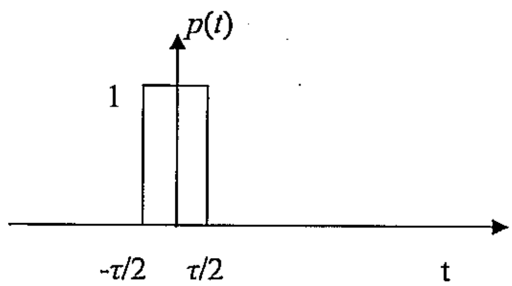


Fig.2(a)

(c) Two signals $y_s(t)$ and $y_p(t)$ are shown in Fig.2(b). $y(t)$ is the common envelope for both $y_s(t)$ and $y_p(t)$.

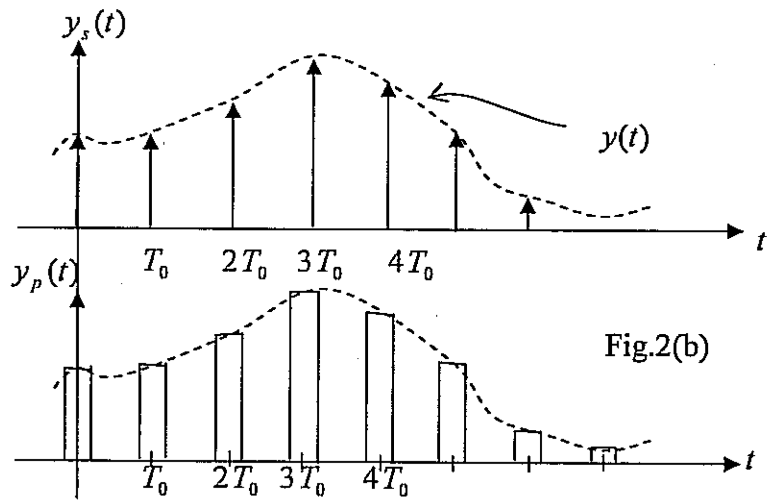


Fig.2(b)

(i) Sketch $f(t) = \sum_{n=-\infty}^{\infty} \delta(t - nT_0)$ [2 *marks*]

(ii) Write an expression for $y_s(t)$ in terms of $y(t)$ and $f(t)$. [2 *marks*]

(iii) $y_p(t)$ is generated by *pulse amplitude modulating* $y(t)$ using a rectangular pulse train. Using the result of (b) derive an expression for $y_p(t)$ in terms of $p(t)$, $f(t)$ and $y(t)$. [3 *marks*]

(iv) Derive an expression for $Y_p(\omega)$ in terms of $P(\omega)$ and $Y(\omega)$. [5 *marks*]

(v) If $Y(\omega) = e^{-\frac{\omega^2}{2}}$ sketch $Y_p(\omega)$ (No calculations are required. $P(\omega)$ is a *sinc* function). [3 *marks*]

3.

(a) (i) Sketch any periodic signal $s(t)$ and mark important points with their values on your diagram. [2 *marks*]

(ii) $s(t)$ can be represented by the equation $s(t) = \sum_{n=-\infty}^{\infty} C_n e^{jn\omega_0 t}$.

(α) With reference to the sketch of $s(t)$ in (i), explain how would you calculate ω_0. [2 *marks*]

(β) Write an expression for C_n in terms of $s(t)$. [2 *marks*]

(iii)

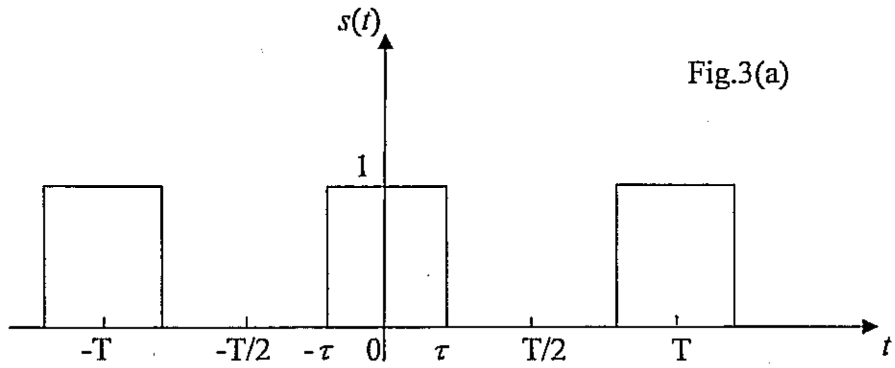


Fig.3(a)

Express $s(t)$ as *a Fourier series* and sketch $|C_n|$ vs. $n\omega_0$ [3 *marks*]

(b) (i) Find *the Fourier Transform* of a pulse $q(t)$ having a pulse width T and a height of unity [1].

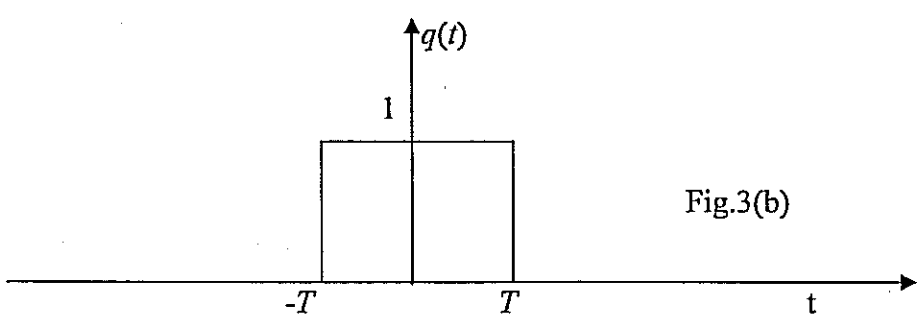


Fig.3(b)

(ii) What is the *Fourier Transform* of $f(t) = 1$? [1 *mark*]

(c) (i) Use the result of (b)(ii) and the *time shifting* property of *Fourier Transform*, to find the *Fourier Transform* of $x(t) = \cos\omega_0 t$.

$(\omega_0 = \dfrac{\pi}{2T})$ [3 *marks*]

(ii) *Cosine pulse* $x_p(t)$ is defined as

$$x_p(t) = x(t) \text{ if } |T| \le 0$$
$$= 0 \text{ otherwise}$$

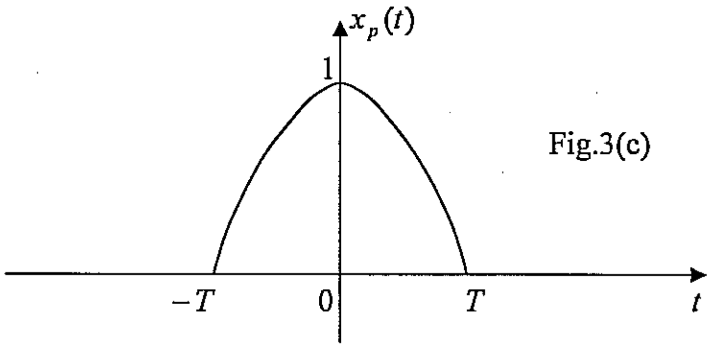


Fig.3(c)

(α) Write the relationship between $x(t)$, $x_p(t)$ and $q(t)$. [2 *marks*]

(β) Using the result of (α) find $X_p(\omega)$ the *Fourier Transform* of $x_p(t)$. [3 *marks*]

(γ) Sketch $X_p(\omega)$ and briefly explain how the shape of $X_p(\omega)$ varies with the width of the pulse ($2T$). [2 *marks*]

4.
(a)

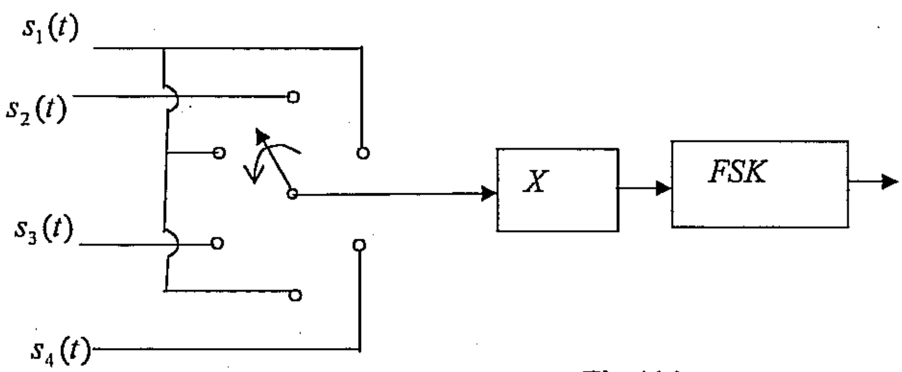


Fig.4(a)

Four signals $s_1(t)$, $s_2(t)$, $s_3(t)$ and $s_4(t)$ are time division multiplexed as shown in Fig.4(a). The Fourier transforms of $s_1(t)$, $s_2(t)$, $s_3(t)$ and $s_4(t)$ are given below:

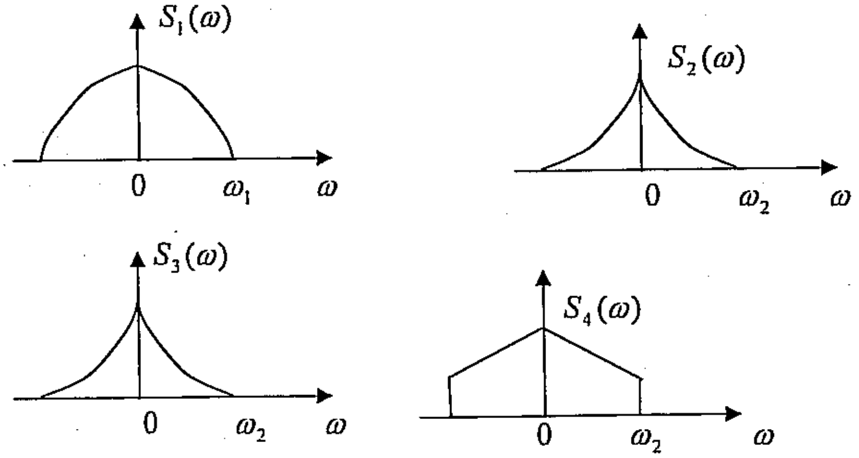


Fig.4(b)

(i) What is *X*? Briefly explain its function. [2 *marks*]

(ii) Where does the *FSK* output go to? [2 *marks*]

(iii) If 120 samples per second are coming to the input of *X*, find the maximum possible values for ω_1 and ω_2. [5 *marks*]

(b) The Electric field intensity (E_θ) of a transmitting antenna at a given distance is given by $E_\theta = k\sin^2\theta$. (Fig.4(c))

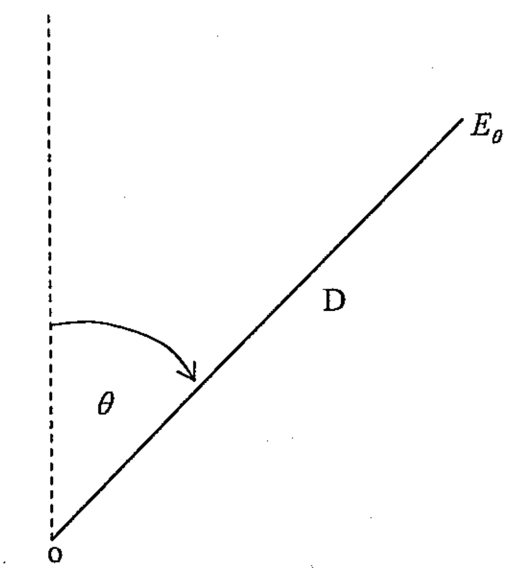


Fig.4(c)

(i) Sketch the radiation pattern of the antenna and find the beam-width. [4 *marks*]

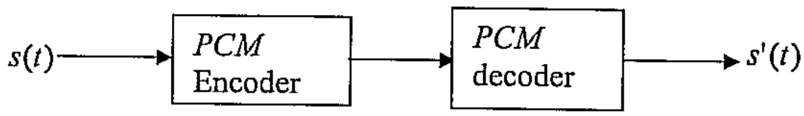
(ii) What is *front to back ratio*? [3 *marks*]

(c) A home antenna consists of a folded dipole, a reflector and two directors. Reception of a certain TV channel is maximized by rotating the antenna. If the reception is still not satisfactory, what modifications to the antenna system can be done in order to further improve reception? [4 *marks*]

5.

(a) A sinusoidal signal $s(t) = A_m \sin \omega t$ is pulse code modulated (*PCM*) using a sequence of n bits. Then the resulting pulse code modulated signal is fed to a *PCM* decoder as shown below in Fig.5(a)

Fig.5(a)



(i) Explain why $s'(t)$ is different from $s(t)$. [2 *marks*]

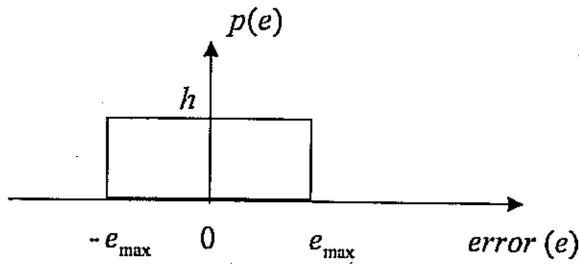


Fig.5(b)

(ii)

Distribution of the error ($e = s'(t) - s(t)$) is uniform as shown in Fig5.(b). $p(e)$ is the probability density function.

(α) Find the values of e_{max} and h. [4 *marks*]

(β) Indicate the type of noise present in the signal $s'(t)$ and find the noise power N. [4 *marks*]

(γ) Show that the signal to noise ratio at the output of the *PCM* decoder (expressed in *dB*) is a linear function of n. [4 *marks*]

(b) A radio transmitter transmits the bit stream 1010 using rectangular pulses. It was observed that the received signal is a distorted signal.

(i) Give two possible causes for the distortion of the signal during transmission. [3 *marks*]

(ii) With the help of suitable sketches explain with justifications, how the above factors (given in (i)) change the shape of the received bit stream. [3 *marks*]

6.

(a)

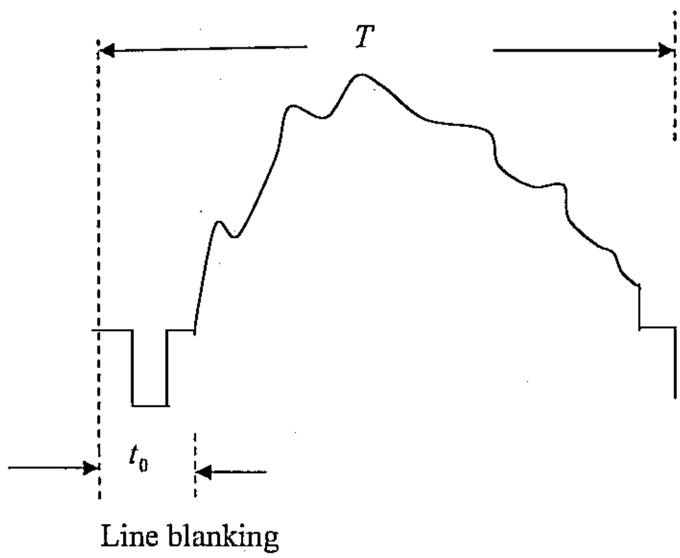


Fig.6

A Black and white *TV* color signal is shown in Fig.6.

A *TV* picture using *PAL* system consists of N lines.
N_0 lines are lost per field due to *field blanking*. (2 fields make one picture).
Aspect ratio of the screen is $4/3$.

(i) Why is line blanking necessary? [3 *marks*]

(ii) Derive an expression for the maximum theoretical video bandwidth using the above data. [8 *marks*]

(b) A high resolution black and white color *TV* picture consists of 3×10^6 picture elements. Each picture element can have 32 different brightness levels.

(i) Find the average information content stored in a picture element. [3 *marks*]

(ii) If pictures are repeated at the rate of 32 per second, calculate the average rate of information conveyed by the TV picture source. [6 *marks*]

7.

(a)

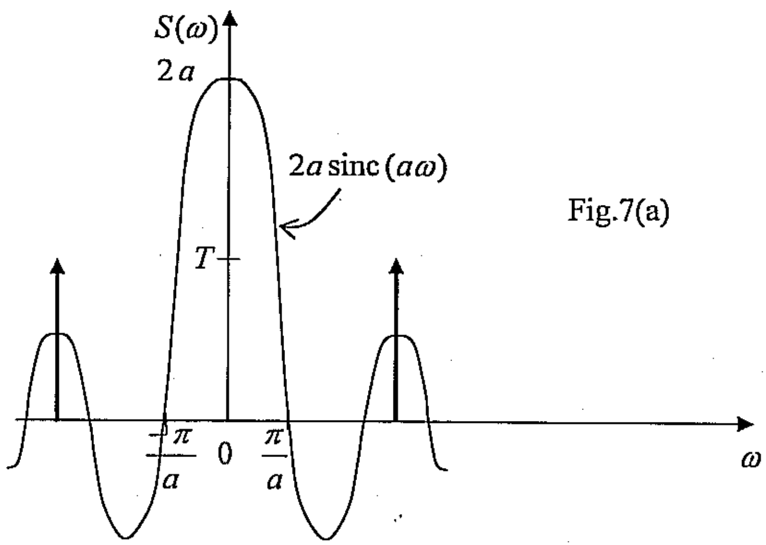


Fig.7(a)

The spectral density function $S(\omega)$ of a random signal consists of a sinc function and two *Dirac* impulses as shown in Fig.7(a).

(i) Write an expression for $S(\omega)$. [3 *marks*]

(ii) Find *the autocorrelation function* $\Re(\tau)$. [5 *marks*]

(iii) Find the average signal power. [3 *marks*]

(b)

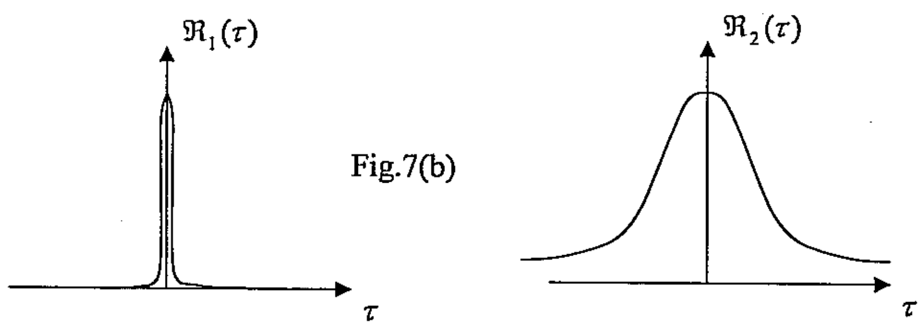


Fig.7(b)

Fig.7(b) shows autocorrelation functions of two *stationary random processes*.

(i) What is meant by *a stationary random process*? [3 *marks*]

(ii) Consider two random processes:

Process A : random variable $x(t)$ is the output value of a random signal generator.
Process B : random variable $y(t)$ is the room temperature

Select the autocorrelation functions of $x(t)$ and $y(t)$ from Fig.7(b). Justify your answer. [6 *marks*]

8.

(a) A transmitter transmits one of the following voltage levels with equal probability: -2 V, -1 V, +1 V and +2 V. The transmitted signal $s(t)$ is received as $x(t)$ at the receiver. Due to addition of noise during the transmission, the received amplitude is different from the amplitude of the transmitted signal. Hence the received signal is sent to *a threshold detector* to minimize the effect of added noise.
From the value of $x(t)$ *the threshold detector* decides for corresponding value of $s(t)$ using the following criterion:

If $x(t) < -1\ V$ then $s(t) = -2\ V$

If $-1\ V < x(t) < 0.5\ V$ then $s(t) = -1\ V$
If $0.5\ V < x(t) < 2\ V$ then $s(t) = +1\ V$
If $2\ V < x(t)$ then $s(t) = +2\ V$

The probability density function $p(n)$ of noise $n(t)$ is given Fig.8(a).

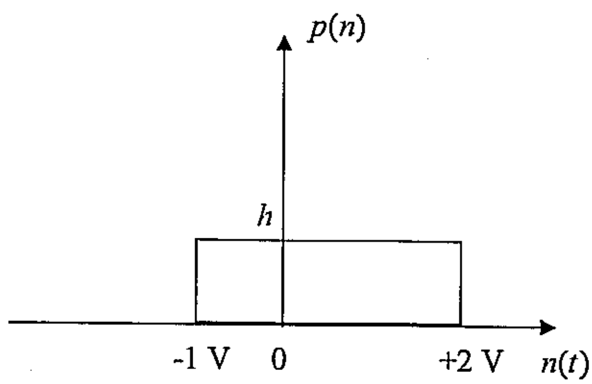


Fig.8(a)

(i) Find the value of h. [2 *marks*]

(ii) Find the average power P_s of the transmitted signal $s(t)$. [3 *marks*]

(iii) Find the average noise power P_n. [3 *marks*]

(iv) Derive an expression for total received signal power P_x, in terms of P_s and P_n assuming that $s(t)$ and $n(t)$ are independent. [3 *marks*]

(v) Find P_x. [2 *marks*]

(vi) What is the probability that -1 V is detected as +1 V? [3 *marks*]

(b) Two binary channels are cascaded as shown in the Fig.8(b). Transition probabilities for various values of x_i and y_j are indicated in the diagram.

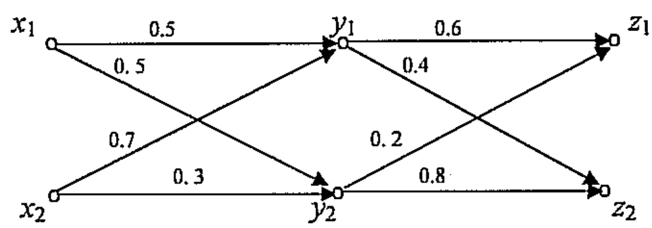


Fig.8(b)

Find the overall channel matrix of the resultant channel and draw the resultant equivalent channel diagram. [4 *marks*]