The Institution of Engineers – Sri Lanka

PART II –2012 JULY - REPEAT EXAMINATION

211 – COMMUNICATION SYSTEMS

Time Allowed: 3 hours

INSTRUCTIONS TO CANDIDATES

1. This paper has 5 pages and contains 7 questions.
2. Answer any **five (05)** questions.
3. All questions carry equal marks.

Question 01

(a) Find the trigonometric Fourier series of a regular square pulse train whose period is $1/F_0$ and pulse width is $1/f_0$ (where $f_0 > F_0$).
(Hint: Choose time origin wisely)

(b) Hence show that

(i) The amplitude spectrum of this square pulse train is a series of spectral amplitudes placed at regular intervals and find this interval.

(ii) The amplitudes are included within a series of lobes of equal width and find that width.

(c) (i) Show that the number of spectral components within each lobe is given by f_0/F_0

(ii) Hence, calculate the pulse width of a periodic square wave of period 10 μs to have 100 spectral components within a single lobe.

For a periodic signal x(t) with fundamental frequency F, the trigonometric Fourier series components a_n and b_n are given by

$$a_n + j\, b_n = 2F \int_{-1/2F}^{1/2F} x(t) exp(+j2.\ nFt)dt$$

Question 02

(a) (i) State the relation between the n^{th} time derivative of a continuously differentiable signal and the Fourier transform of that signal (proof is not necessary)

(ii) Define the transfer function of a linear system.

(b) The input voltage $v_i(t)$ mV and the output voltage $v_o(t)$ mV of a passive linear network where 't' is measured in milliseconds, are related by the differential equation

$$v_i = v_O + \frac{2}{\pi^2}\frac{d^2 v_O}{dt^2} + \frac{3}{\pi}\frac{dv_O}{dt}$$

(i) Find the transfer function of this network.

(ii) This network is known to be made by cascading two linear passive networks. The frequency response of one of these networks is given in Figure Q2. Find the transfer function of the other network.

(c) A system is formed by cascading two identical networks whose transfer function is the reciprocal of the transfer function found in (b)(ii) above. Deduce the differential equation that relates the input and output voltages of this system.

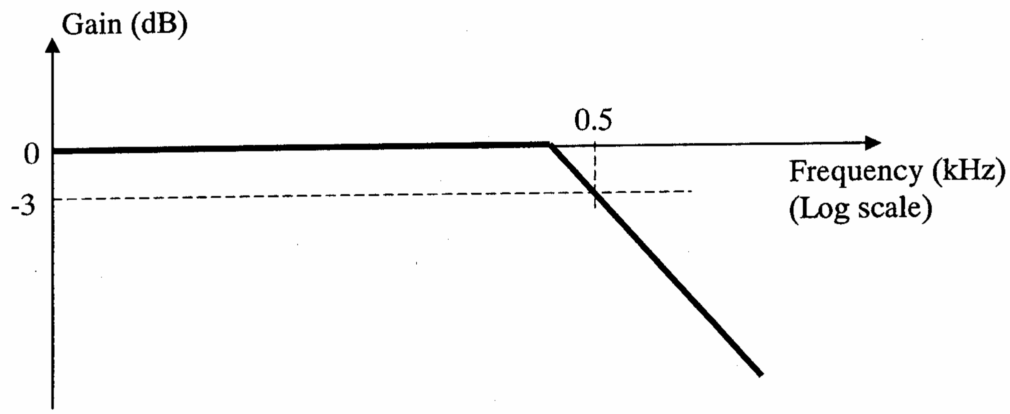

Figure Q2

Question 03

(a) Define the term 'depth of modulation' as applicable to amplitude modulation.

(b) The modulation efficiency 'χ' of an amplitude modulator is defined as the ratio between the carrier power and the total power of the modulated signal. Find χ as a function of m where m is the depth of modulation when the carrier is modulated by a single tone.

(c) Amplitude modulation is used to transmit an alarm tone given by $V_m(t) = 0.5\cos(200\pi t)$ mV.

(i) Calculate the minimum amplitude of the carrier that should be used if the modulation efficiency 'χ' of the modulator should exceed the value 32/41.

(ii) Briefly describe an improvement that could be used to make this transmission more power efficient

Question 04

(a) (i) Define the Dirac-delta function or the impulse function that is encountered in communication theory.

(ii) State the duality or reciprocity property of Fourier transforms.

(b) (ii) Using first principles, find the Fourier transform of a unit amplitude pulse of width 'τ', symmetric about the time origin.

(iii) Using the result of (b)(ii) above, deduce that the frequency domain representation of an ideal DC source is a delta function.

(c) Using the duality property of Fourier transforms, briefly explain why it is not possible to realize an impulse function in practice.

Question 05

(a) (i) Explain what is meant by quantization in digital communication systems.

(ii) Define quantization noise in a linearly quantized pulse code modulator

(b) For a linearly quantized pulse code modulator that produces 'N' bits per sample, the Signal to Quantization Noise Ratio is defined as

$$SQNR = \frac{3}{2} 2^{2N}$$

The maximum peak to peak value of the analog input is 32 mV and the quantization step of the modulator is 125 μV. Calculate the SQNR of this modulator in dB.

(c) By referring to the statistical properties of the amplitude of a typical speech signal, briefly explain why linear quantization is not suitable in practice.

Question 06

(a) A lossless transmission line has an inductance of l H and a capacitance of c F per unit length. Show that both the voltage and the current on a point located at a distance x m measured from the transmitting end along the line satisfies the linear differential equation,

$$\frac{d^2y}{dx^2} + \beta^2 y = 0$$

and find β in terms of l and c.

(b) (i) Define the characteristic impedance of a transmission line

(ii) Using the results of (a) above, show that the characteristic impedance of a lossless line is purely resistive.

(c) A lossless transmission line of length 50 m is tested in a laboratory. With one end short circuited, the resistance of the line measured at the other end was found to be 140.5 Ω . When the measurement was repeated with the other end open circuited, the reading was 40.0 Ω

(i) Calculate the characteristic impedance of the line.
(ii) If the capacitance of the line is 122 μF, find its inductance.

Question 07

(a) Describe the advantages of using digital modulation schemes to transmit digital base band signals over a band limited channel

(b) (i) Show that for an M-ary PSK system or an M-ary QAM system the signaling rate at the modulator output is

$$X / \log_2 M$$

where X bps is the input bit rate and M is a power of 2.

(ii) A 64 kbps signal is to be transmitted over telephone channel. Find a suitable type of modulator that could be used to achieve this purpose.

(c) A PSK digital radio link has a working bandwidth of 30 MHz and is used to carry a 150 Mbps digital baseband. The noise in the channel is likely to cause a maximum phase error of 10^0.

(i) Find the optimum modulation scheme that the modulators on either end of the link should use.

(ii) If the scheme in (c)(i) above is to be replaced by a two amplitude QAM scheme, find the percentage increase in the phase error due to noise, that could be tolerated.