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National Exams May 2013

07-Elec-A3, Signals and Communications

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.
2. This is a Closed Book Exam but one aid sheet is allowed written on both sides. An approved calculator is permitted.
3. There are six questions, however, FIVE (5) questions constitute a complete paper. The first five questions as they appear in the answer book will be marked.
4. All questions are of equal value.
5. Clarity and organization of the answer are important.

1. **(Total 20 marks)** Consider a discrete-time linear time invariant system that is described by the following difference equation:

$$\frac{1}{16}y[n-2] - \frac{1}{2}y[n-1] + y[n] = 2x[n-1] + x[n],$$

where $y[n]$ and $x[n]$ are output and input sequences respectively.

   (a) **(10 marks)** Find the impulse response of the system $h[n]$.

   (b) **(10 marks)** Draw the simulation block diagram in direct form II of the system.

2. **(Total 20 marks)** Figure 1, (a) and (b) shows the input $x(t)$ and the impulse response $h(t)$ for a linear time invariant (LTI) system, using the graphical convolution find and sketch the output signal $y(t)$.

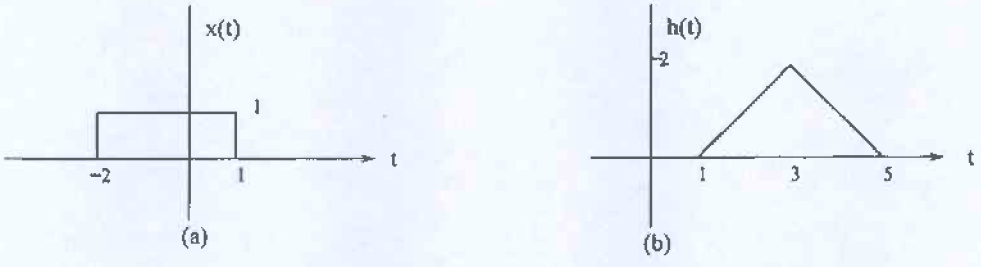

Figure 1:

3. (20 marks total)

   (a) (10 marks) Find the exponential Fourier series for the signal $x(t)$ in Fig. 2.

   (b) (10 marks) Find the Fourier series coefficients of this signal, D_n, and plot the magnitude and phase of D_n for $-7 \leq n \leq 7$.

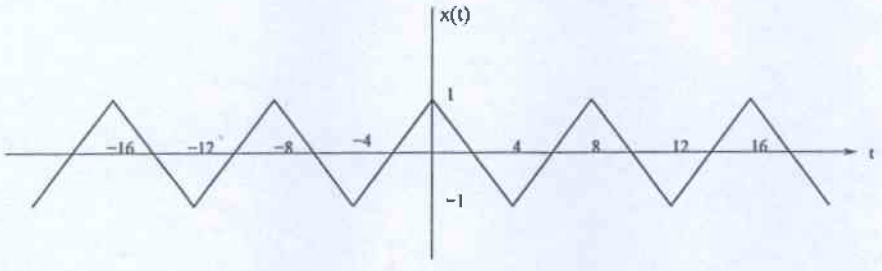

Figure 2:

4. **(Total 20 marks)** For the following signals, sketch each signal $x(t)$, find its Fourier Transform $X(j\omega)$, and sketch the magnitude and phase spectrum.

   (a) **(10 marks)** $x(t) = e^{-2|t-1|}$

   (b) **(10 marks)** $x(t) = te^{-2|t|}$

5. **(Total 20 marks)** The following signals are used to generate DSB-SC (double-sideband suppressed carrier) AM signals. Which signals can be recovered using envelope detection? Justify your answer.

   (a) **(5 marks)** $x(t) = 2\cos(2\pi f_1 t)$

   (b) **(5 marks)** $x(t) = \cos(2\pi f_1 t) + \cos(2\pi f_2 t)$

   (c) **(5 marks)** $x(t) = 2 + \cos(2\pi f_1 t)$

   (d) **(5 marks)** $x(t) = 2 + 2\cos(2\pi f_1 t) + \cos(2\pi f_2 t)$

6. For each of the following baseband signals:

   (i) $m(t) = \cos 2000t$
   (ii) $m(t) = 3\cos 2000t + \cos 4000t$
   (iii) $m(t) = \cos 2000t \cos 6000t$

   (a) **(3 marks)** Sketch the spectrum of $m(t)$.

   (b) **(6 marks)** Sketch the spectrum of the DSB-SC signal $m(t)\cos(10,000t)$.

   (c) **(3 marks)** Identify the upper sideband (USB) and the lower sideband (LSB) spectra.

   (d) **(8 marks)** Identify the frequencies in the baseband, and the corresponding frequencies in the *DSB-SC*, *USB*, and *LSB spectra*. Explain the nature of frequency shifting in each case.