OLLSCOIL NA hÉIREANN, GAILLIMH
NATIONAL UNIVERSITY OF IRELAND, GALWAY

AUTUMN EXAMINATIONS 2001

THIRD YEAR ELECTRONIC ENGINEERING

EE308 SIGNALS AND COMMUNICATIONS

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Duration of Examination: **THREE** hours
Instructions: Answer **FIVE** questions

1.

(a)

(i) What is an LTI system? **[4 marks]**
(ii) Explain the term "orthogonal basis function" for signals. **[4 marks]**
(iii) State Parseval's theorem for periodic functions. **[2 marks]**

(b) Obtain the exponential Fourier series representation of the periodic signal $f(t) = e^{-t}$ as shown in Fig. 1. Sketch the magnitude and phase spectra of the signal. **[10 marks]**

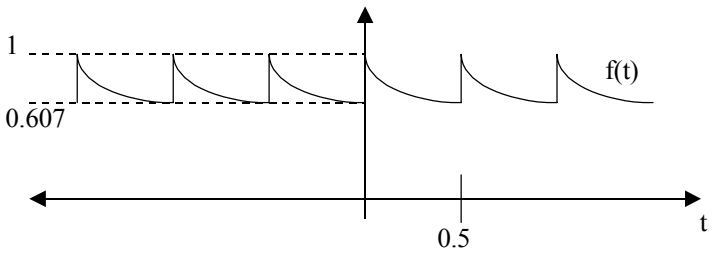

Fig. 1.

2.

(a) Obtain the trigonometric Fourier series representation of the signal $x(t) = t^2$ over the interval (0, 2), which repeats with a frequency of 0.5 Hz. What is Gibbs' phenomenon, and explain whether it applies to the signal x(t) or not. **[10 marks]**

(b) Prove that the trigonometric Fourier series of the even function s(t) as shown in Fig. 2 is given by:

$$s(t) = \frac{4}{\pi} \sum_{\substack{n=1 \\ n\,odd}}^{\infty} \frac{1}{n^2} \cos(nt)$$ over the interval $(-\pi, \pi)$.

Define half-wave symmetry, and explain if the signal s(t) displays this property or not. **[10 marks]**

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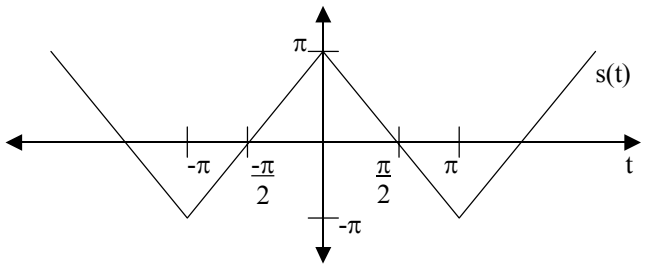

Fig. 2.

3.

(a) Name and prove the following properties of the Fourier transform:

(i) $\Im\{f^*(t)\} = F^*(-\omega)$. **[3 marks]**

(ii) If $\Im\{g(t)\} = G(\omega)$, then $\Im\{G(t)\} = 2\pi g(-\omega)$. **[4 marks]**

(iii) $\Im\{s(\alpha t)\} = \frac{1}{|\alpha|} S\left(\frac{\omega}{\alpha}\right)$. **[3 marks]**

(b)

(i) Find the Fourier transform of the function $x(t) = \left(1 - 2e^{-t}\right)[u(t) - u(t-2)]$. **[7 marks]**

(ii) If $\text{rect}(t) \Leftrightarrow \text{Sa}(\omega/2)$, determine the Fourier transform of $\text{Sa}(t/2)$. **[3 marks]**

4.

(a)

(i) Draw the magnitude and phase spectra corresponding to the frequency response of an ideal low pass filter with cutoff frequency ω_c. **[3 marks]**

(ii) What is the principle of causality? Does it hold for the impulse response of an ideal LPF? **[4 marks]**

(iii) Explain the difference between a band pass filter and the passband of a filter. **[3 marks]**

(b)

(i) Explain what is meant by the "-3 dB bandwidth" of a filter. **[2 marks]**

(ii) If the magnitude of the frequency transfer function of an nth order Butterworth filter is:

$$|H(j\omega)| = \frac{1}{\sqrt{1 + \left(\frac{\omega}{\omega_0}\right)^{2n}}},$$

what is the DC gain? **[1 mark]**

(iii) Compute the ratio of the –60 dB to –6 dB bandwidths for the first, second, third and fourth order Butterworth filters with ω_0 = 1 rad/s. **[7 marks]**

[cont'd]

5.

(i) What is meant by the term "modulation"? **[2 marks]**

(ii) What is the general equation for a bandpass signal, and define a bandpass signal for normal AM. **[2 marks]**

(iii) Define both the modulation index m and the efficiency η of a normal AM signal. **[3 marks]**

(iv) Fig. 3 shows a modulating or message signal m(t). Sketch an example of a normal AM modulated signal for each of the following three cases. **[6 marks]**

- $m < 1$
- $m = 1$
- $m > 1$

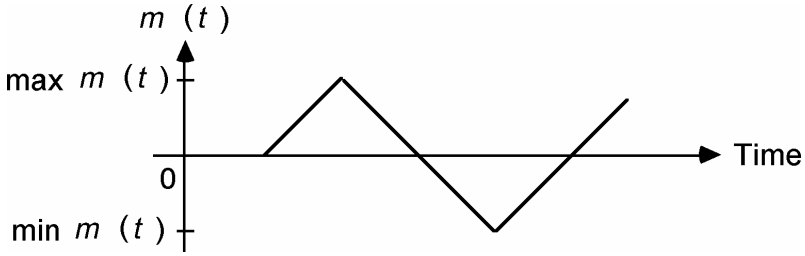

Fig. 3

(v) If m(t) as shown in Fig. 3 has a maximum value of 10 and a minimum value of –9, what are the range of values of A (the amplitude of the carrier signal) that will cause overmodulation of a normal AM signal? **[2 marks]**

(vi) Draw the circuit diagram for a normal AM envelope detector, and explain with the aid of a waveform diagram how a message signal is recovered from a modulated signal using this circuit. **[5 marks]**

6.

(a) Define the modulation index β and the peak frequency deviation Δf for FM with a sinusoidal modulating signal. **[2 marks]**

(b)

(i) An angle modulated signal using FM has an angular carrier frequency ω_c = 3000 rad/s, and a peak frequency deviation of 600 Hz. If the modulating signal is given by the equation $f(t) = 30\cos(160\pi t)$, determine the bandwidth of the FM signal using Carson's rule. **[6 marks]**

(ii) What type of angle modulated signal results if $\beta << 1$, and what is the bandwidth of such a signal? **[2 marks]**

(c) With the aid of a block diagram, describe the steps involved in the indirect method for generating a wideband FM signal. **[8 marks]**

(d) Fig. 4 illustrates the direct method of generating a wideband FM signal. What is the function of the empty block in the middle, and what is it called? **[2 marks]**

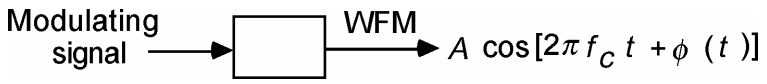

Fig. 4

[cont'd]

7.

(a)

(i) Define a band limited signal. **[2 marks]**

(ii) State the sampling theorem. **[2 marks]**

(iii) What is the Nyquist sampling rate? **[1 mark]**

(iv) What is meant by interpolation? **[1 mark]**

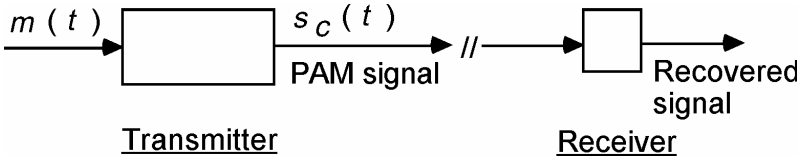

Fig. 5

(b) What is PAM? Name the empty blocks in the PAM system shown in Fig. 5. **[3 marks]**

(c) Table 1 shows the practical sampling frequency values for audio and broadcast signals. Complete the values missing from this table in your answer book. **[3 marks]**

Signal	f_m	*Minimum* f_s	*Practical* f_s
Audio	3.3 kHz		
Music	20 kHz		
TV	4 MHz		

Table 1

(d) One of the basic problems in communication engineering is the design of a pulse communication system which allows signals from many users to be transmitted simultaneously over a single communication channel. Explain using diagrams what TDM is and how it can be used as a solution to this problem. **[8 marks]**