OLLSCOIL NA hÉIREANN, GAILLIMH
NATIONAL UNIVERSITY OF IRELAND, GALWAY

SEMESTER I EXAMINATIONS 2002/2003

THIRD YEAR ELECTRONIC ENGINEERING
THIRD YEAR ELECTRONIC AND COMPUTER ENGINEERING

EE308 SIGNALS AND COMMUNICATIONS

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

1.

(a) Define the following:

(i) LTI system **[3 marks]**.

(ii) Gibbs' effect **[3 marks]**.

(iii) Parseval's theorem for periodic functions **[3 marks]**.

(b) A periodic square wave function x(t) is shown in Fig. 1.

(i) Obtain the *exponential* Fourier series representation of x(t) **[6 marks]**.

(ii) Derive expressions for both the magnitude and phase spectra of x(t), and sketch these over the $-5 < n < 5$ range **[5 marks]**.

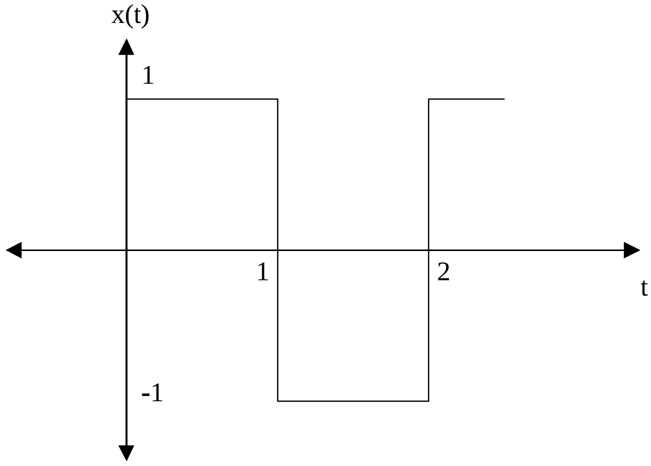

Fig. 1.

[cont'd]

2.

(a) Define half wave symmetrical and quarter wave symmetrical signals, and explain how the trigonometric Fourier series can be simplified for each type **[8 marks]**.

(b) A periodic triangle wave f(t) is shown in Fig. 2.

(i) Obtain the *trigonometric* Fourier series representation of f(t) **[10 marks]**.

(ii) Is this function either odd or even, and explain why this is so **[2 marks]**?

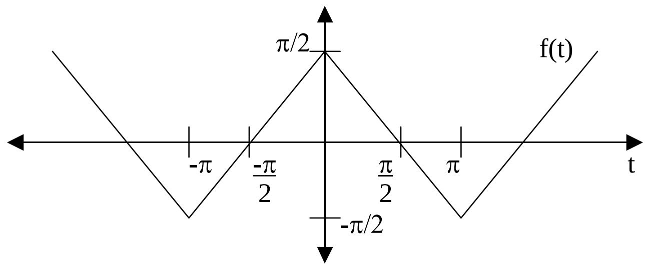

Fig. 2.

3.

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

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

(ii) If $\Im\{g(t)\} = G(\omega)$, then $\Im\{G(t)\} = 2\pi g(-\omega)$ **[3 marks]**.

(iii) $\Im\{x(t-t_0)\} = X(\omega)e^{-j\omega t_0}$ **[3 marks]**.

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

(b) An aperiodic sawtooth waveform s(t) is shown in Fig. 3.

(i) Derive the Fourier transform of s(t) **[7 marks]**.

(ii) What type of spectrum would you get if you plotted S(ω) **[1 mark]**?

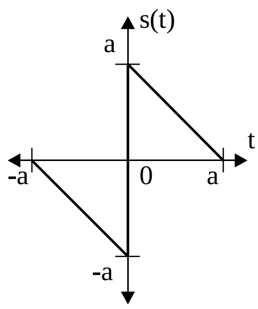

Fig. 3

[cont'd]

4.

(a)

(i) Draw the magnitude and phase spectra corresponding to the frequency responses for *both* an ideal low pass filter *and* an ideal high pass filter with cutoff frequencies ω_c **[4 marks]**.

(ii) What is the principle of causality? Does it hold for the impulse response of an ideal LPF **[2 marks]**?

(iii) What is the expression for the magnitude of the frequency response of an n^{th} order Butterworth filter with cutoff frequency ω_0 **[1 mark]**? What is the DC gain of such a filter **[1 mark]**?

(iv) Explain the difference between a band pass filter and the passband of a filter **[2 marks]**.

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

(b)

(i) Sketch the circuit diagram for a Sallen-Key second-order low-pass active filter **[3 marks]**.

(ii) Such a filter is designed to give a Butterworth-type response with f_0 = 7 kHz. If the value of R = 1 kΩ, calculate suitable values for C and k **[5 marks]**.

5.

(a) By modelling a noisy resistor as a voltage source in series with an ideal resistor, derive an expression for the RMS noise voltage out of a noisy resistor R when it is connected in parallel with a capacitor C. Make use of the fact that the power spectral density of the output noise is an even function of frequency, and also note that $\int_0^\infty \frac{1}{x^2 + a^2}\,dx = \frac{1}{a}\tan^{-1}\left(\frac{x}{a}\right)$ **[8 marks]**.

(b) What are the PSD and autocorrelation functions for both ideal and bandwidth-limited white noise **[4 marks]**?

(c) Define the four average quantities used to describe random signals **[8 marks]**.