

OLLSCOIL NA hÉIREANN, GAILLIMH
NATIONAL UNIVERSITY OF IRELAND, GALWAY

SEMESTER I EXAMINATIONS 2000/2001

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) Explain the following terms: (i) LTI system, (ii) orthogonal basis function. Also, state Parseval's theorem for periodic functions.
- (b) Obtain the exponential Fourier series representation of the rectangular pulse train $f(t) = \text{rect}(t/\tau)$ as shown in Fig. 1. Sketch the amplitude spectrum of the signal for $\tau/T = 1/5$.

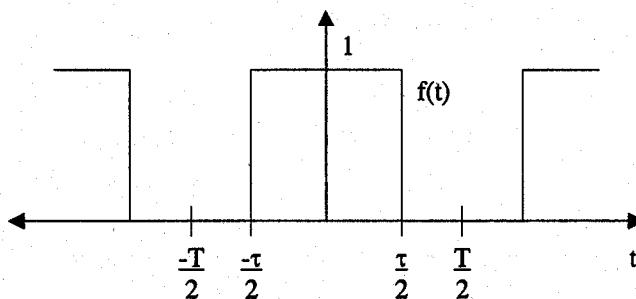


Fig. 1.

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

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

Define half-wave symmetry, and explain if the signal $s(t)$ displays this property or not.

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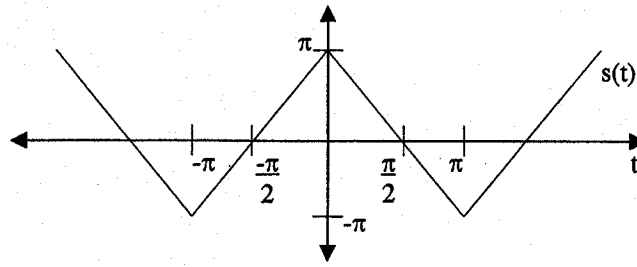


Fig. 2.

3.

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

- (i) $\mathfrak{F}\{f^*(t)\} = F^*(-\omega)$.
- (ii) If $\mathfrak{F}\{g(t)\} = G(\omega)$, then $\mathfrak{F}\{G(t)\} = 2\pi g(-\omega)$.
- (iii) $\mathfrak{F}\{f(t - t_0)\} = F(\omega)e^{-j\omega t_0}$.

(b) Find the Fourier transform of the function $x(t) = e^{-a|t|}$, where $a > 0$.

Sketch the resulting spectrum for $a = 0.8$. What is the difference between the spectra of periodic and aperiodic signals?

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 .
- (ii) What is the principle of causality? Does it hold for the impulse response of an ideal LPF?
- (iii) Explain the difference between a band pass filter and the passband of a filter.

(b) Explain what is meant by the “-3 dB bandwidth” of a filter. If the magnitude of the frequency transfer function of an n th order Butterworth filter is:

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

what is the DC gain? Compute the ratio of the -60 dB to -6 dB bandwidths for the first, second and third order Butterworth filters with $\omega_0 = 1$ rad/s.

5.

- (a) Describe the following physical sources of noise: (i) thermal noise, and (ii) shot noise. In both cases, give an approximate expression for the power spectral density.
- (b) 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:

$$\int_0^{\infty} \frac{1}{x^2 + a^2} dx = \frac{1}{a} \tan^{-1}\left(\frac{x}{a}\right)$$