ICP4710

Queen Mary and Westfield College

UNIVERSITY OF LONDON

MSci EXAMINATION

SIGNAL PROCESSING PHY-971

22 MAY 1998 10:00

Time allowed: TWO HOURS

Answer **TWO** questions only. No credit will be given for attempting a further question.

Each question carries 20 marks. The mark *provisionally allocated* to each section is indicated in the margin.

TURN OVER WHEN INSTRUCTED

1 State the *convolution theorem*, both in the time domain and the frequency domain, and outline the derivation of the relation between them. **[6 marks]**

(a) A linear electrical system has an impulse response which is a square pulse of magnitude A and duration T_1. Find and sketch the frequency response of the system, both in magnitude and phase. **[4 marks]**

(b) Explain why it is impossible to devise a circuit having uniform frequency response from $\omega=0$ to some value ω_1 and zero elsewhere. If a circuit approximates to this frequency response, what happens to its time response? **[3 marks]**

(c) The circuit of (a) is fed with a single square pulse of magnitude B starting at time $t=0$ and of duration T_2, where $T_2 \leq T_1$. Draw a quantitative sketch of the time dependence of the output of the circuit. **[3 marks]**

(d) If it is fed instead with a continuous train of square pulses of magnitude B and duration T_1 and repeating at time intervals $\tau=3T_1$, what is the frequency spectrum of the output signal? **[4 marks]**

2 Define the correlation function between two signals $g(t)$ and $f(t)$ varying with time t. What is the relation between their Fourier transforms? **[4 marks]**

(a) Suppose $f(t) = A\cos(\omega_1 t + \delta_1)$ and $g(t) = B\cos(\omega_1 t + \delta_2)$. Find the correlation function ρ_{fg} between them, averaged over a long time T, which may be taken to be an exact number of oscillations. Also find its Fourier transform. Comment on the variation with $\delta_1 - \delta_2$. **[5 marks]**

(b) Suppose that, due to instrumental resolution or the properties of the sources, the correlation function is averaged over a range $\pm\Gamma$ of $\delta_1 - \delta_2$. Find and sketch the effect on the average correlation function. **[3 marks]**

Describe the Michaelson stellar interferometer and discuss the relevance of the preceding results to its mode of operation. In particular, discuss the dependence of fringes on mirror separation and the effect this has on fringe visibility. What is the effect of the fact that the star has a circular profile? **[8 marks]**

go to next page

3 Write notes on **two** of the following topics: **[10 marks each]**

(a) The dependence of noise on amplitude and on frequency, and the relation of both to the autocorrelation function; the use of autocorrelation in separating signal from noise; how noise may be used to measure the frequency response $H(\omega)$ of a system.

(b) The Abbé theory of the microscope and the phase contrast microscope.

(c) The Fabry-Perot interferometer and the effect of multiple reflections.

(d) Amplitude modulation and its relation to convolution; the diffraction grating as a modulator.

Examiner: D.V Bugg

Last page