

U14710

Queen Mary and Westfield College

UNIVERSITY OF LONDON

MSci EXAMINATION

CONTROL AND STABILITY

PHY-975

5 MAY 1998 14:30

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.

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- 1 Discuss the Nyquist criterion for the stability of a control system using negative feedback. Explain the meaning of *phase margin* and *gain margin*; what values are desirable for these quantities in a practical system? [8 marks]

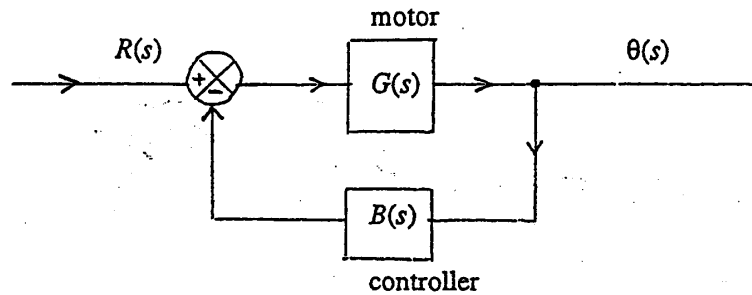


Figure 1

A motor is used with a feedback controller as shown in Figure 1 to control the angular position θ of a load, in response to an input signal R . The response function of the motor is $G(s) = 1/[s(s + \beta)]$ and the controller has response function $B(s) = A/(s + \alpha)$ with α positive. For what values of α is θ unstable, and what is then the frequency of oscillation? [6 marks]

The motor may be used instead with a different $B(s) = A(s + \gamma)$ to run with angular velocity $\omega = d\theta/dt$, in response to a step function input of magnitude R . Show that

$$\omega(s) = \frac{R}{s^2 + s(\beta+1) + \alpha}$$

At what value of ω does the motor settle? What is the condition required for critical damping of the angular velocity ω ? [6 marks]

go to next page

- 2 Outline, with an example, what is meant by the *Z-transform* of a digital system. What is the relation between the Nyquist angular frequency ω_N and the sampling interval T ? How is the stability of the system related to the location of poles and zeros of the *Z-transform*? Discuss one example. What is the impulse response to a pole at $z = 1$? [8 marks]

A causal digital system has zeros at $z = 0.9e^{i\pi/4}$ and $z = 0.9e^{-i\pi/4}$. It samples the input at regular time intervals T . Find and sketch

(a) the impulse response $h(t)$; [4 marks]

(b) the magnitude squared of the frequency response $|H(\omega)|^2$. [6 marks]

What input waveform will produce a δ -function output? [2 marks]

- 3 Write an essay on one of the following topics: [20 marks]

(a) The performance of the three-term controller.

(b) Pole-zero cancellation, including one physical example.

(c) The FIR filter, adaptive filters, and neural networks.

(d) the bilinear transformation from analogue to digital systems; illustrate this with one example.