GX949

Ollscoil na hÉireann, Gaillimh
National University of Ireland, Galway

Semester II Examinations, 2004/2005

Exam Code(s)	2BN,2BP,2BM,2BI
Exam(s)	2nd Engineering
Module Code(s)	EE202
Module(s)	Electrical Circuits and Systems
Paper No.	
Repeat Paper	
External Examiner(s)	Professor S. McLaughlin
Internal Examiner(s)	Professor. D.J. Wilcox
Instructions:	Answer 3 questions
Duration	2hrs
No. of Answer books	
Requirements:	
Handout	
MCQ	
Statistical Tables	
Graph Paper	Yes Ordinary cm graph paper
Log Graph Paper	Yes 3-cycle log-linear (Code: 5531)
Other Material	
No. of Pages	
Department(s)	Electronic Engineering

1. *(a)* Derive, from first principles, the nature of the BODE plot (both gain and phase) of the second order transfer function:

$$G(s) = \frac{\omega_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2}$$

and derive a formula for the exact gain @ $\omega = \omega_n$. **[8 marks]**

(b) Using the log-linear graph paper supplied, use straight-line sections to approximate the BODE plot of the transfer function:

$$G(s) = \frac{160}{(s^2 + 2s + 16)(s + 20)}$$

Use separate sheets for the gain and phase characteristics. Refine the gain characteristic by appropriate rounding at the corner frequencies. Similarly refine the initial phase characteristic to an approximate smooth curve. **[10 marks]**

(c) Use your BODE plot to predict (approximately) the steady-state output responses to the following inputs:

(i) $\sin(t)$, *(ii)* $\sin(4t)$, and *(iii)* $\sin(10t)$ **[2 marks]**

2. *(a)* Explain the basic organizational structure of an electricity power supply system for getting power from power stations to consumers. Why is it uneconomic to provide power to local consumers directly from the HV grid? What is the function of an electricity substation? and why are several different voltage levels used in a power supply system? How is power flow affected if a transmission line is brought down in a storm? **[10 marks]**

(b) An MV transmission line of impedance $Z = (4 + j10)\Omega$ feeds into a regional (MV/LV) substation which draws 40MVA at a power factor of 0.9 lagging (see Fig.2). The voltage at the remote end of the line is measured to be 76kV. Determine the MVA, voltage, and power factor at the sending-end of the line. What is the efficiency of the power transfer? **[10 marks]**

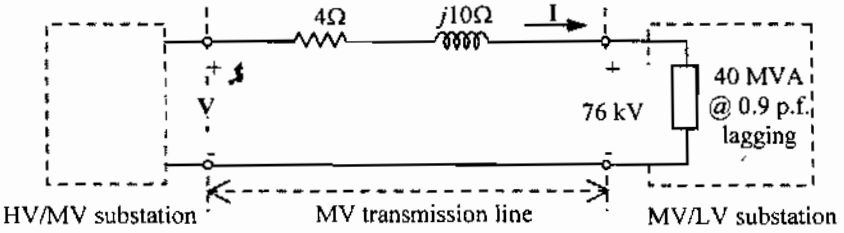
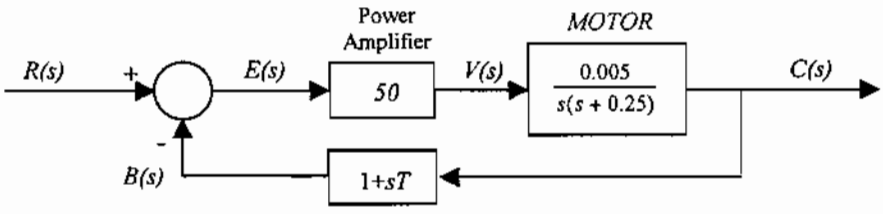


Fig.2

3. *(a)* Draw a block diagram showing the structure of a single-input single-output feedback control system, labelling and explaining the signals involved. Describe the dynamic action of feedback control, using the illustrative case where an aircraft is required to maintain an altitude of 30,000 feet. **[10 marks]**

(b) Show that the system of Fig.3 has the transfer function: $\frac{C(s)}{R(s)} = \frac{0.25}{s^2 + 0.25(1+T)s + 0.25}$

Sketch the unit step response of the system for the cases *(i)* $T = 0$ and *(ii)* $T = 3$ seconds. Comment on the effectiveness of using tachometric feedback. **[10 marks]**



Tachometric feedback

Fig.3

4. *(a)* By a process of systematic block diagram reduction, show that the system in Fig.4 has the transfer function $G(s) = \frac{C(s)}{R(s)} = \frac{(s+2)K}{s^3 + 1.25s^2 + (K+0.25)s + 2K}$. **[8 marks]**

(b) Use the Routh-Hurwitz Criterion, or otherwise, to determine the value of K (> 0) at which the system just becomes unstable. What will be the frequency of the unstable oscillations? **[4 marks]**

(c) If $K = 0.18$, $G(s)$ has one pole at $s = -1.15$ and a pair of conjugate poles at $s = -0.05 \pm j0.56$. Specify $G(s)$ in this case and draw its pole-zero map. For this case, specify the undamped natural frequency ω_n of the dominant poles of the system and the corresponding damping ratio ζ. Sketch the unit step response of the system in this case. **[8 marks]**

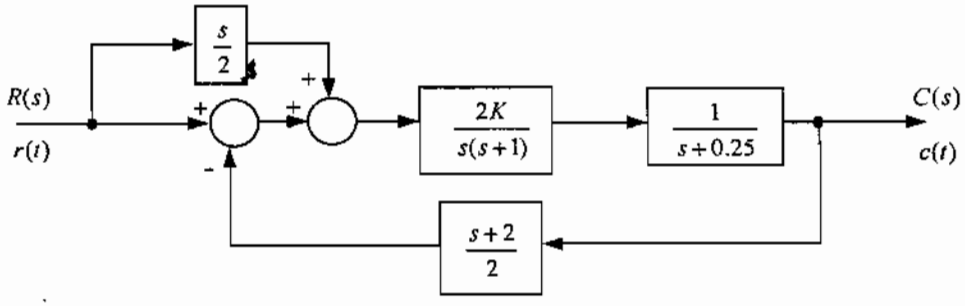


Fig.4