Ollscoil na hÉireann, Gaillimh
National University of Ireland, Galway

GX 689

Semester II Examinations, 2002/2003

Exam Code(s)	2BN121/2BP121/2BI121/2BI221/2BJ121/2BG121/2BM121
Exam(s)	Second Year Electronic Engineering Second Year Electronic & Computer Engineering Second Year Industrial Engineering Second Year Industrial Engineering (Design Stream) Second Year Management Engineering with Language Second Year Mechanical Engineering Second Year Biomedical Engineering
Module Code(s)	EE202
Module(s)	Electrical Circuits and Systems
Paper No.	2
Repeat Paper	Special Paper
External Examiner(s)	Professor S. McLaughlin
Internal Examiner(s)	Professor. D.J. Wilcox Mr. M. Glavin

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)		

1. *(a)* Describe how thermal energy is converted to electrical power in a conventional power station. Comment on the efficiency of the energy conversion process. **[6 marks]**

   (b) Explain why bulk electrical power is transmitted at high voltage in Power Networks. Briefly discuss the economic advantages of sending 400MW at 400kV rather than sending the same amount of power at a generator voltage of 40kV (assume single-phase transmission at unity power factor). **[6 marks]**

   (c) An MV feeder supplies an MV/LV substation with 50MW of real power and 25MVA$_r$ of reactive power as shown in Fig.1. The voltage at the receiving (load) end of the feeder is 55.9kV. *(i)* Specify the MVA and power factor of the feeder load. *(ii)* Determine the value of the feeder current. *(iii)* Calculate the amounts of real and reactive power absorbed by the feeder itself. *(iv)* Determine the voltage V_S at the sending end of the feeder. **[8 marks]**

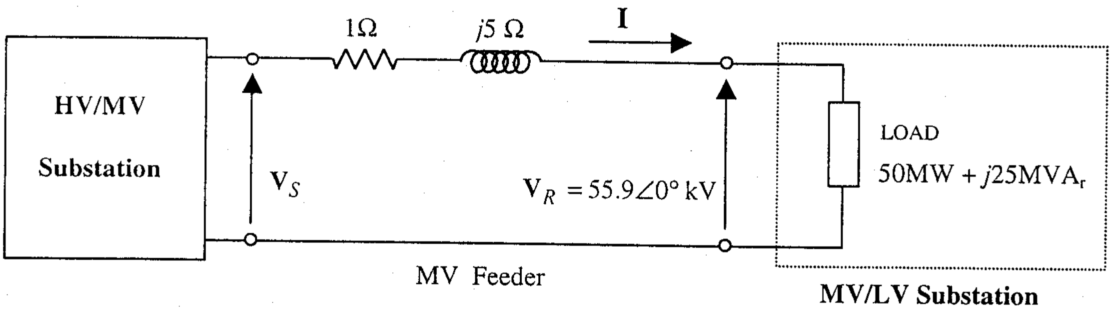

Fig.1

2. Fig.2 shows an electrical circuit with input $v_{in}(t)$ and output $v_{out}(t)$.

   (a) Show that the circuit has the transfer function

$$\frac{V_{out}(s)}{V_{in}(s)} = \frac{200}{s^2 + 30s + 400}$$ **[5 marks]**

   (b) Specify the frequency response function of the circuit. Use this to calculate the steady-state output voltage of the circuit when the input is $v_{in}(t) = 6\sin(20t)$ Volts. **[4 marks]**

   (c) In your answer book, sketch the BODE plot (gain and phase) of the frequency response of the circuit [no need to use log-linear graph paper]. **[6 marks]**

   (d) In your answer book, sketch the unit step response of the circuit showing reasonable detail, including the final value and the timescale involved. **[5 marks]**

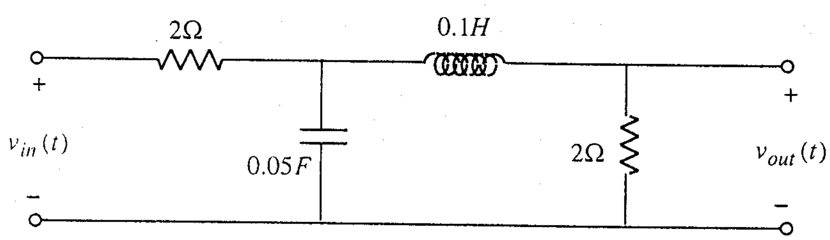

Fig.2

3. *(a)* Draw a diagram showing the structure of a general closed-loop control system, labelling the signals involved. Describe the dynamics of a closed-loop control system, using the illustrative case where the plant is an oven whose temperature is to be controlled. [**8 marks**]

(b) Fig.3 shows the block diagram representation of a position-control servomechanism with integral-action control. Show that the closed-loop transfer function of the system is given by

$$\frac{\theta_{out}(s)}{\theta_{in}(s)} = \frac{K}{s^3 + s^2 + sTK + K}$$

where T and K are design parameters ($T > 0$, $K > 0$) . [**2 marks**]

(c) Using the Routh-Hurwitz criterion, or otherwise, show that the system will be unstable unless $T > 1$ sec, regardless of the value of K. [**4 marks**]

(d) The controller is now given settings of $T = 2$ sec and $K \approx 0.28$. Confirm that the closed-loop system will then have poles at $s \approx -0.125 \pm j0.6$ and at $s \approx -0.75$ [**2 marks**]. Draw the pole-zero map of the transfer function, and sketch the unit step response of the system showing reasonable detail (including the time scale involved, the final value, and the nature of any decaying oscillations). [**4 marks**]

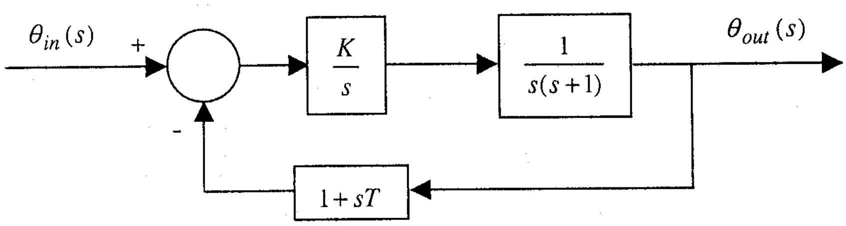

Fig.3

4. *(a)* By a process of systematic block diagram reduction, show that the system in Fig.4a has the transfer function $\dfrac{C(s)}{R(s)} = \dfrac{5K}{s^3 + 8s^2 + 16s + 5 + 5K}$. [**8 marks**]

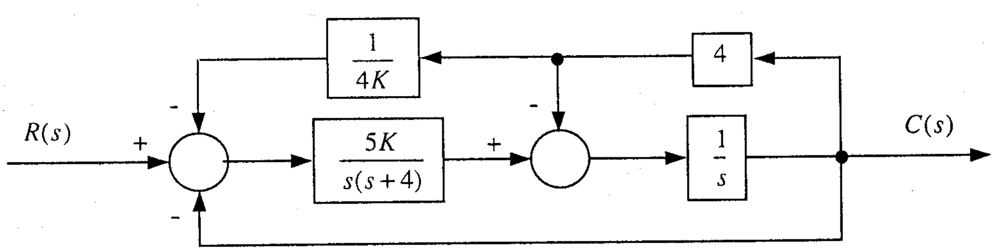

Fig.4a

(b) Tests on the system in Fig.4b gave the frequency-response results shown in the table. Plot the results onto log-linear graph paper and proceed to deduce the transfer function of the system. **12 marks**]

Frequency (rad/s)	0.1	0.5	2.0	4.0	10.0	50.0
Gain	-26dB	-12dB	-3dB	-1dB	0dB	0dB

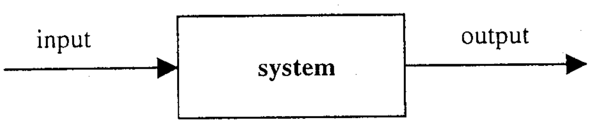

Fig.4b