National Examinations, December 2002

98-Elec-B1, Advanced Circuits Analysis and Design

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.
2. Candidates may use one of the approved Casio or Sharp calculators. No programmable calculators are allowed. This is a closed-book examination.
3. Any five questions constitute a complete paper. Only the first five questions, as they appear in your answer book, will be marked.
4. All questions are of equal value; part marks are also indicated.
5. Refer to the appendix for extra information.

Question 1:
In figure-1, the switch was open for a long time. At t=0, the switch is closed. Using a differential equation approach, **(a)** write the differential equation involving $v_{o(t)}$. **[10]**

(b) Solve the differential equation to find the output voltage, $v_0(t)$ for $t > 0$. **[10]**

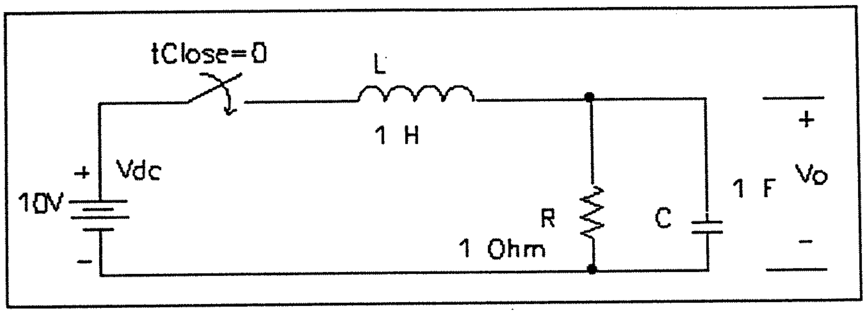


Figure-1

Question 2:
(a) Obtain the transfer function, $T(s) = \dfrac{Y(s)}{X(s)}$ of the following signal flow block diagram. **[10]**

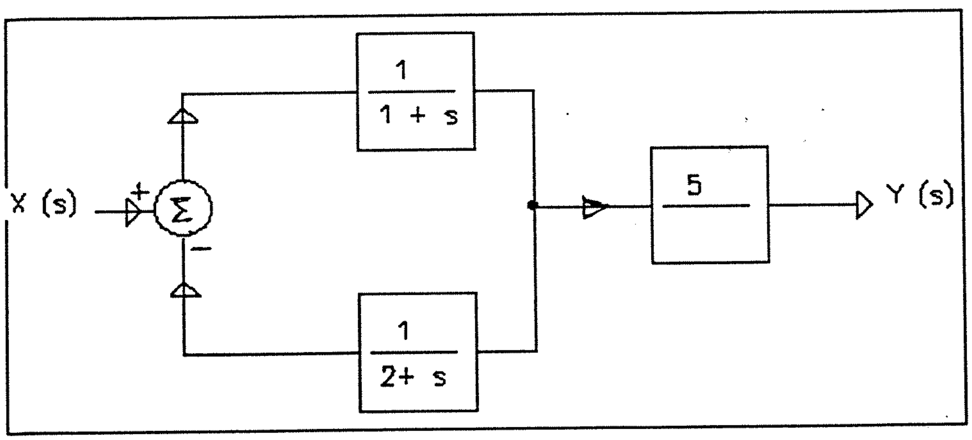


Figure-2

(b) Plot the poles and the zeros of the transfer function, and from the locations of the poles and zeros, state whether the system will be stable and what type of transient time response the output will display. **[10]**

Question 3:

If the transfer function of a circuit is $H(s) = \frac{V_0(s)}{V_{in}(s)} = \frac{5000(s+1)}{s(s+10)(s+50)}$,

(a) draw the Bode plot (amplitude and phase), showing clearly the break frequencies. **Please use the graph paper provided in the appendix.** **[12]**

(b) If $v_{in}(t) = 10\cos 200t$, calculate $v_o(t)$. **[8]**

Question-4:

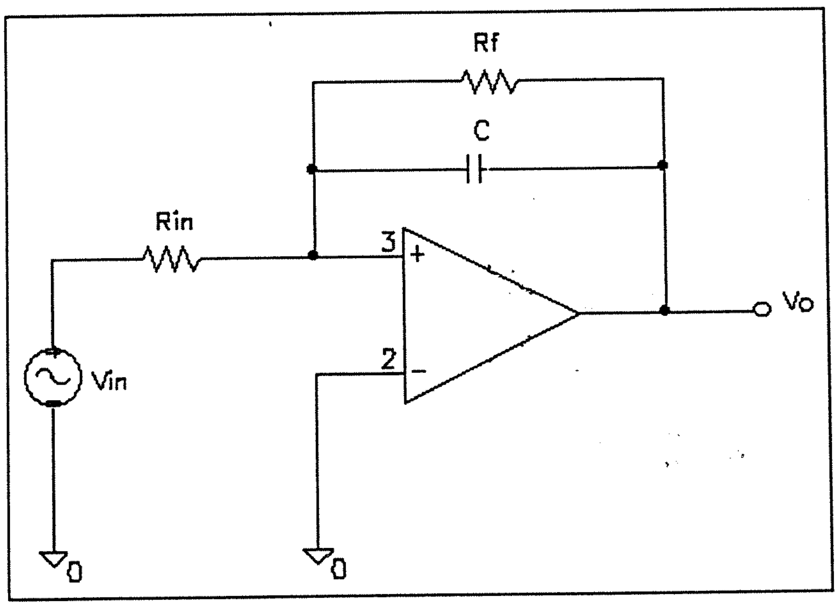


Figure -3

Figure –3 shows a circuit with an opamp.
(a) Derive an expression of its transfer function H(s) in terns of C, R_f and R_{in}. **[10]**
(b) If C = 1 uF, R_f = 10 kΩ and R_{in} = 1 kΩ, calculate its cutoff frequency, f_c. **[5]**
(c) Sketch its Bode (amplitude) plot, and from this plot, state what type of filter this circuit will perform. **[5]**

Question 5:
Obtain the transfer function, H(s) of a Butterworth filter to approximate the following 'Brickwall' specifications.

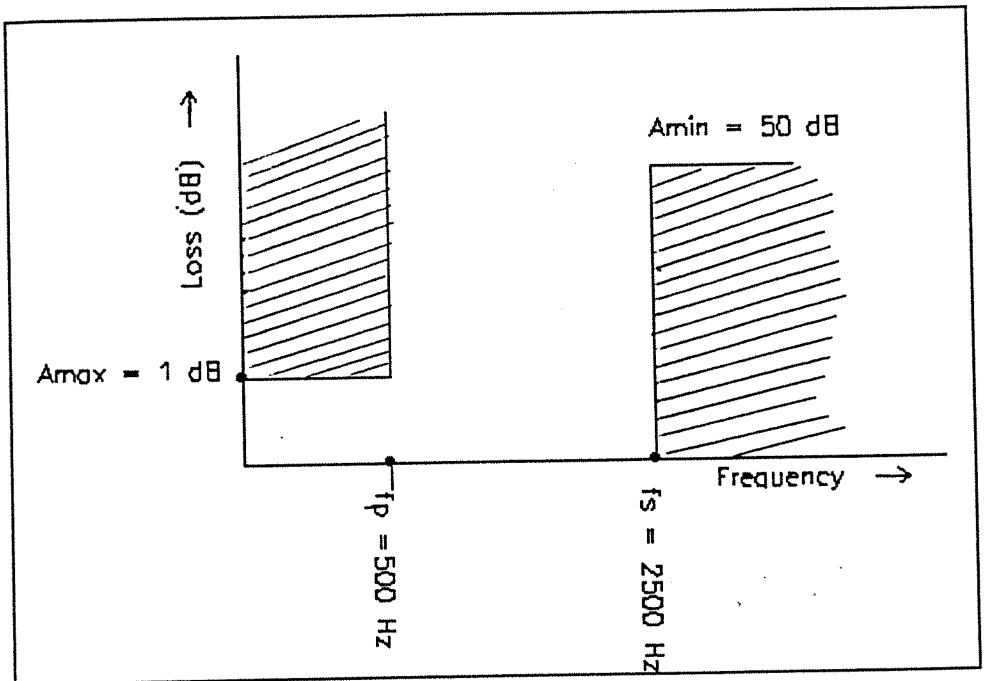


Figure -4

The relevant filter equations are provided in the appendix. **[20]**

Question 6:

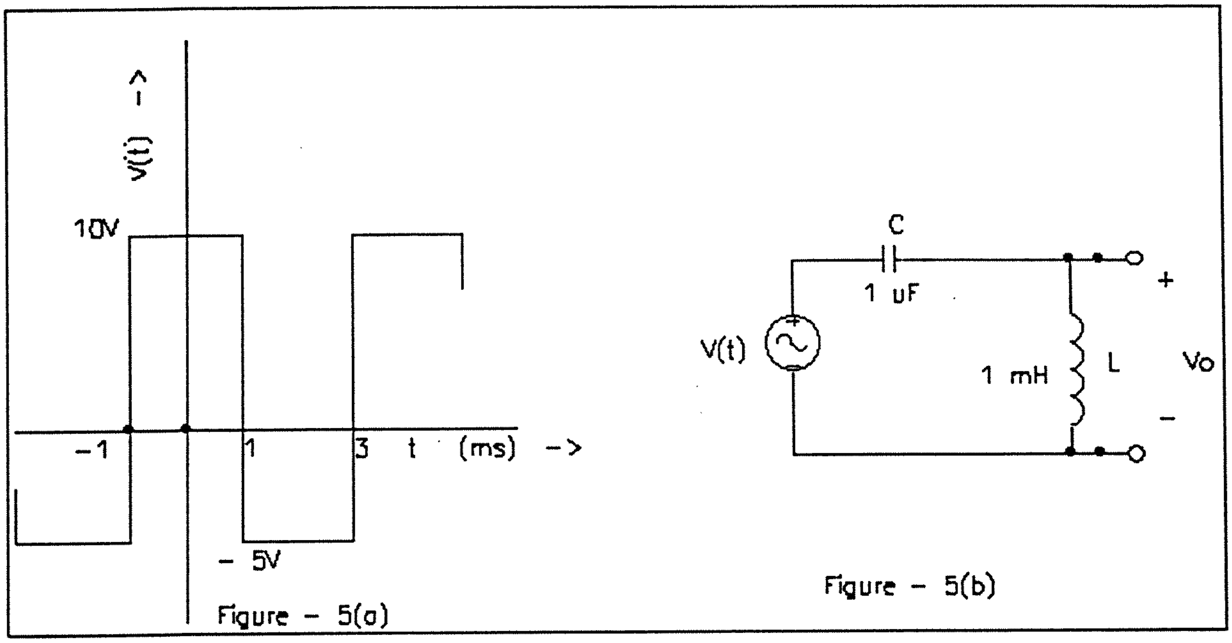


Figure - 5(a) Figure - 5(b)

(i) For the waveform of V(t) shown in Figure –5(a), calculate its frequency componenets upto the 3rd harmonics. **[10]**

(ii) If V(t) is applied to the circuit shown in Figure – 5(b), calculate its output voltage V_o due to the 3rd harmonic. **[10]**

Question 7:

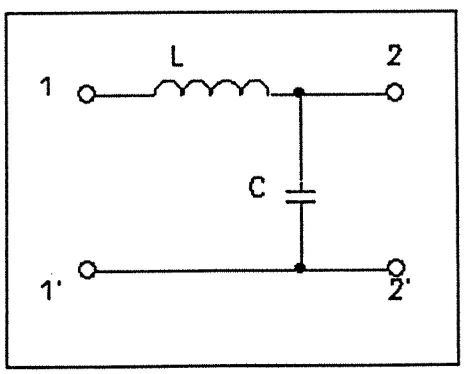


Figure-6

Figure-6 shows a two-port network. **(a)** Calculate its [T] – transmission line parameters. **[10]**

(b) If two of the L-sections of lines are connected in cascade i.e. one section connected to the next section, calculate its overall [T] parameters. **[10]**

Question 8:

A transmission line has the following parameters at 1.5 GHz:

$L = 10$ nH/m $R = 1\ \Omega$/m $G = 0.25 \times 10^{-3}$ mho/m $C = 0.2$ pF/m

Calculate (i) the Characteristic impedance of the line,
(ii) the propagation constant,
(iii) the load impedance to eliminate the reflection from the load.
(iv) if the line is terminated with a load impedance of $100 - j\,50$ Ohms, calculate its reflection coefficient, and the standing wave ratio. [20]

Appendix

Some useful **Laplace Transforms:**

f(t)	→	F(s)
Ku(t)		K / s
e^{-at} u(t)		1 / (s+a)
sin wt .u(t)		w / (s^2+w^2)
cos wt . u(t)		s / (s^2+w^2)
$\frac{df(t)}{dt}$		s F(s) – f(0^-)
$\frac{d^2f(t)}{dt^2}$		s^2F(s) – s f(0^-) –f^1(0^-)
$\int_{-\infty}^{t} f(q)dq$		$\frac{F(s)}{s} + \int_{-\infty}^{0} f(q)dq$

Fourier's series:

$$f(t) = f_{av} + \sum_{n=1}^{\infty}(a_n \cos nw_0 t + b_n \sin nw_0 t)$$

$$f_{av} = \frac{1}{T}\int_0^T f(t)dt$$

$$a_n = \frac{2}{T}\int_0^T f(t)\cos nw_0 t\, dt$$

$$b_n = \frac{2}{T}\int_0^T f(t)\sin nw_0 t\, dt, \quad \text{where} \quad w_0 = \frac{2\pi}{T}$$

For an even function, $a_n = \frac{4}{T}\int_0^{\frac{T}{2}} f(t)\cos nw_0 t\, dt, \quad and \quad b_n = 0$

For an odd function, $b_n = \frac{4}{T}\int_0^{\frac{T}{2}} f(t)\sin nw_0 t\, dt, \quad and \quad a_n = 0$

Filter equations:

Normalized Butterworth Loss Function, L(s)

n	L(s)
1	(s+1)
2	$(s^2+\sqrt{2}s+1)$
3	$(s+1)(s^2+s+1)$
4	$(s^2+0.76537\,s+1)(s^2+1.84776\,s+1)$

$$\Omega_S=\frac{\omega_S}{\omega_P} \qquad \epsilon=\sqrt{10^{0.1L_{\max}}-1} \qquad n\geq\frac{\log_{10}\left(\sqrt{\dfrac{10^{0.1L_{\min}}-1}{10^{0.1L_{\max}}-1}}\right)}{\log_{10}(\Omega_s)}$$

2-port network equations:

$$[T]=\begin{bmatrix}\dfrac{A}{-C} & \dfrac{-B}{D}\end{bmatrix}$$

$$A=\left.\frac{V_1}{V_2}\right|_{I_2=0} \qquad D=-\left.\frac{I_1}{I_2}\right|_{V_2=0}$$

$$B=\left.\frac{V_1}{-I_2}\right|_{V_2=0} \qquad C=\left.\frac{I_1}{V_2}\right|_{I_2=0}$$

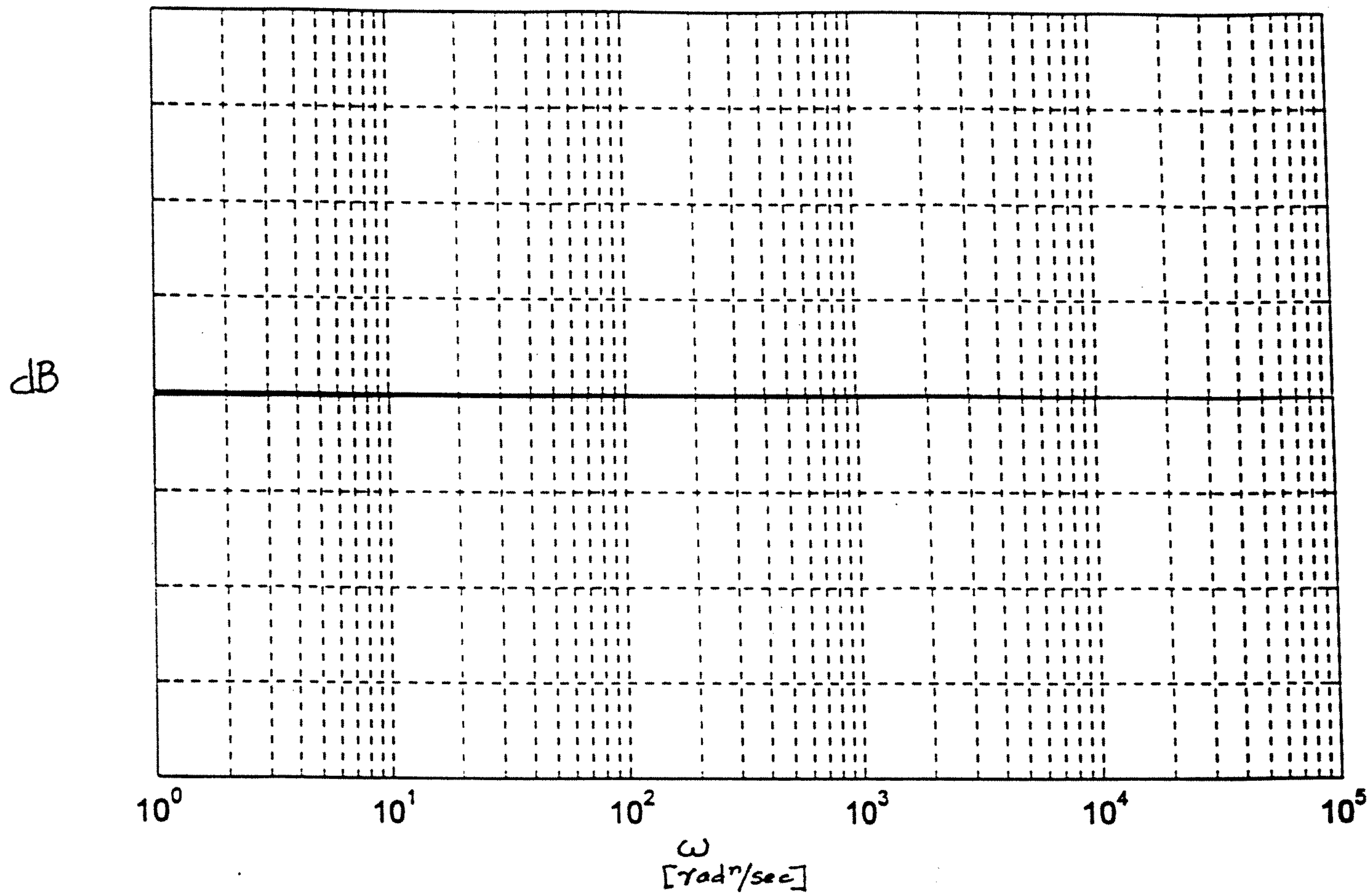
Transmission Line equations:

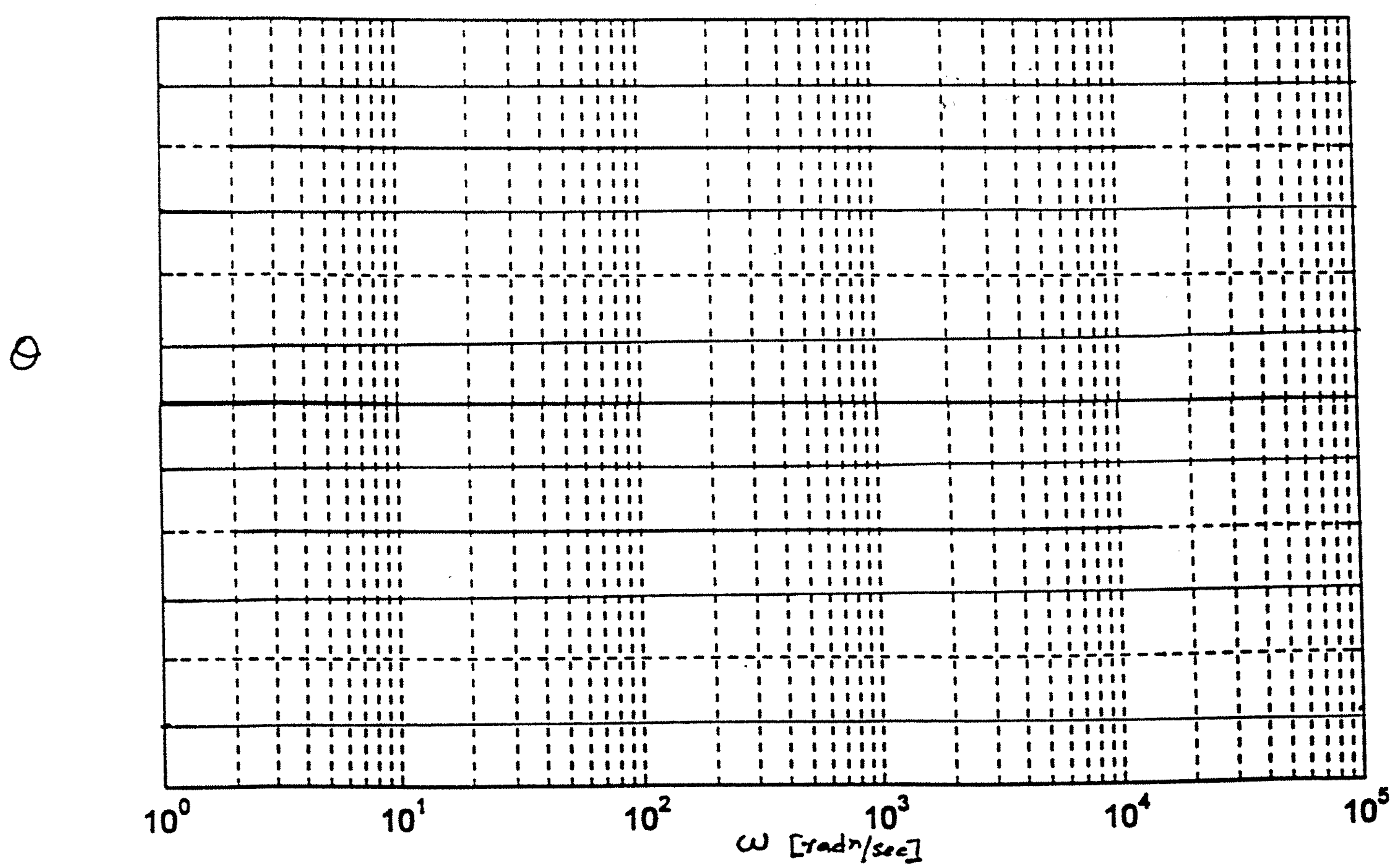
$$Z_c = \sqrt{\frac{R + jwL}{G + jwC}}$$

$$\gamma = \sqrt{(R + jwL)(G + jwL)}$$

$$r = \frac{Z_L - Z_c}{Z_L + Z_c}$$

$$\rho = \frac{1 + |r|}{1 - |r|}$$





[Please use this graph for question #3, and attach with your answer]