National Examinations, May 2003

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, $v_o(t)$ for $t > 0$, if there were on initial charges on C and no initial current in L. [10]

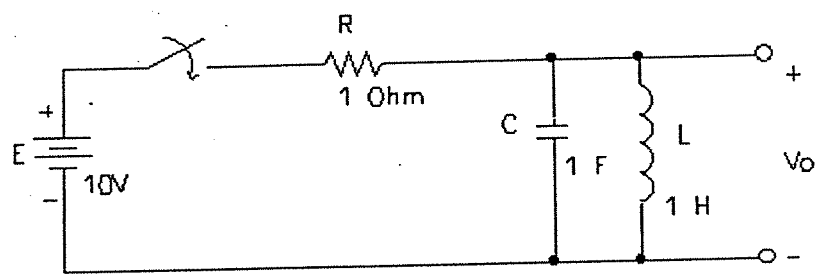

Figure-1

Question 2:

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

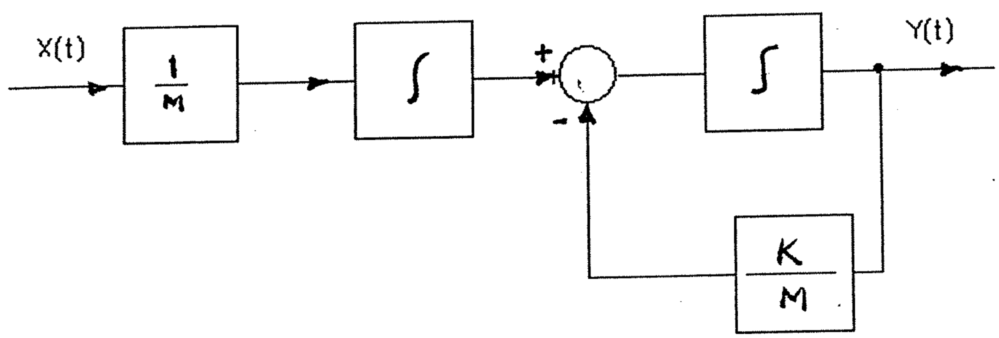

Figure-2

(b) From the transfer function derive the system's differential equation involving, y(t). [4]

(c). If x(t) = 5 u(t), M = 2, K = 1, and at t = 0, y(t) = 0, dy/dt = 10, solve for y(t). [6]

Question 3:

(a) If the transfer function of a circuit is $H(s)=\dfrac{V_0(s)}{V_{in}(s)}=\dfrac{2(s+5)}{s(s+10)^2}$,

draw the Bode plot (amplitude and phase), showing clearly the break frequencies. **Please use the graph paper provided in the appendix in page-10.** [12]

(b) An Amplitude plot in dB of H(s) is shown in **Figure – 3**. Obtain the transfer function, H (s). [8]

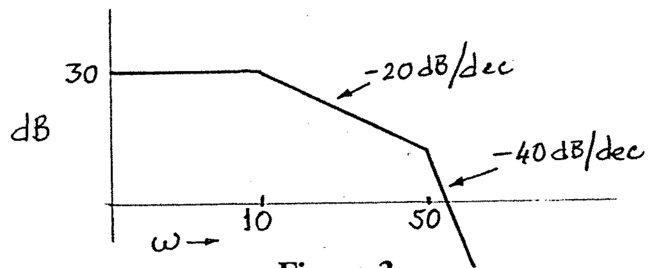

Figure-3

Question-4:

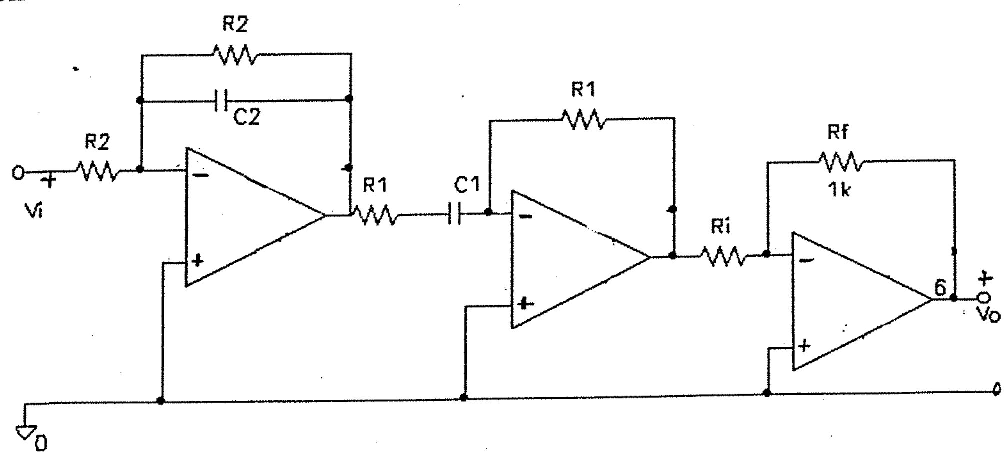

Figure -4

Figure – 4 shows an active filter circuit.

(a) Derive the expression of its transfer function H(s) in terms of ω, capacitors and resistances shown in the circuit. [8]

(b) If R1=5kΩ,C1=0.1uF,R2=1kΩ ,C2=0.01uF,Ri=1kΩ, Rf =100kΩ , find ω_o and Gain at ω_o. [8]

(c) State what type of filter this is. [4]

Question 5:

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

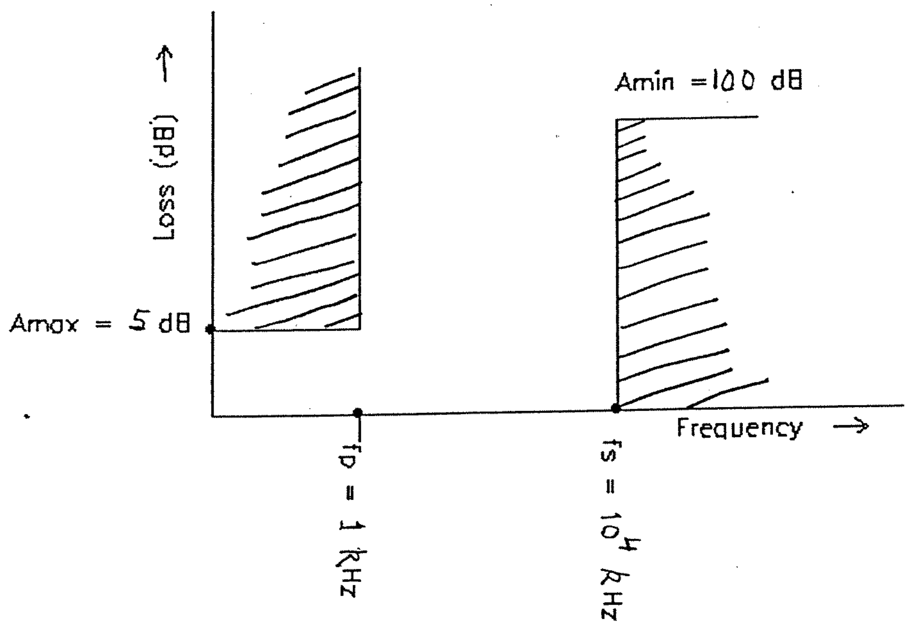

Figure -5

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

Question 6:

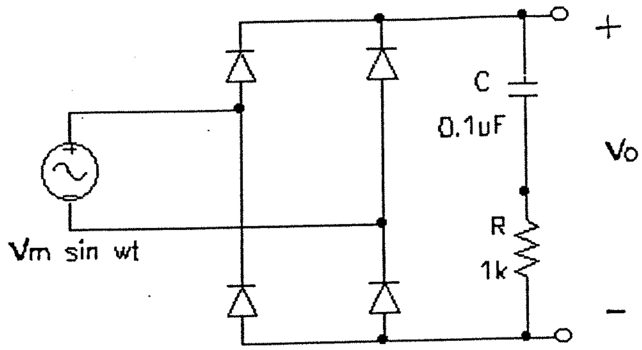

Figure - 6

(i) For the circuit shown in **Figure – 6**, calculate the dc and the fundamental component of the in the output voltage, V_o, if Vm = 10v and frequency of supply is 60 Hz. **[10]**

(ii) Calculate the power dissipation in the RC load for the fundamental component of V0. **[10]**

Question 7:

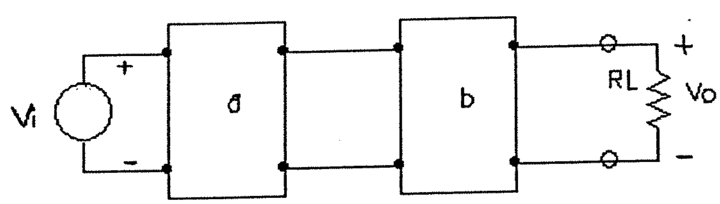

Figure-7

Two port networks [a] and [b] are cascaded as shown in figure-7. If the parameters of the 2-port networks are given as shown below.

$$[Z_a]=\begin{bmatrix}4 & 3\\ 2 & 2.5\end{bmatrix}\ \Omega \quad and \quad [Y_b]=\begin{bmatrix}8 & -2\\ 1 & 5\end{bmatrix}\ S$$

(a) Calculate the overall T - parameters of the circuit. **[10]**

(b) If RL = 2Ω, find the voltage ratio V_o/V_i of the circuit. **[10]**

Question 8:

A transmission line has the following parameters at 2 GHz:

$L = 8$ nH/m $R = 1.1\ \Omega$/m $G = 0.2 \times 10^{-3}$ mho/m $C = 0.1$ 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 $50 - j\,25\ \Omega$, 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^-) – $f^1(0^-)$
$\int_{-\infty}^{t} f(q)dq$		$\frac{F(s)}{s} + \int_{-\infty}^{0} f(q)dq$

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Fourier's series:

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

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

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

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

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	$(s^2+0.76537\,s+1)(s^2+1.84776\,s+1)$

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

2-port network equations

	z-Parameters	y-Parameters	h-Parameters	t-Parameters
z-Parameters	$\begin{bmatrix} z_{11} & z_{12} \\ z_{21} & z_{22}\end{bmatrix}$	$\begin{bmatrix} \frac{y_{22}}{\Delta y} & \frac{-y_{12}}{\Delta y} \\ \frac{-y_{21}}{\Delta y} & \frac{y_{11}}{\Delta y}\end{bmatrix}$	$\begin{bmatrix} \frac{\Delta h}{h_{22}} & \frac{h_{12}}{h_{22}} \\ \frac{-h_{21}}{h_{22}} & \frac{1}{h_{22}}\end{bmatrix}$	$\begin{bmatrix} \frac{t_{11}}{t_{21}} & \frac{\Delta t}{t_{21}} \\ \frac{1}{t_{21}} & \frac{t_{22}}{t_{21}}\end{bmatrix}$
y-Parameters	$\begin{bmatrix} \frac{z_{22}}{\Delta z} & \frac{-z_{12}}{\Delta z} \\ \frac{-z_{21}}{\Delta z} & \frac{z_{11}}{\Delta z}\end{bmatrix}$	$\begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22}\end{bmatrix}$	$\begin{bmatrix} \frac{1}{h_{11}} & \frac{-h_{12}}{h_{11}} \\ \frac{h_{21}}{h_{11}} & \frac{\Delta h}{h_{11}}\end{bmatrix}$	$\begin{bmatrix} \frac{t_{22}}{t_{12}} & \frac{-\Delta t}{t_{12}} \\ \frac{-1}{t_{12}} & \frac{t_{11}}{t_{12}}\end{bmatrix}$
h-Parameters	$\begin{bmatrix} \frac{\Delta z}{z_{22}} & \frac{z_{12}}{z_{22}} \\ \frac{-z_{21}}{z_{22}} & \frac{1}{z_{22}}\end{bmatrix}$	$\begin{bmatrix} \frac{1}{y_{11}} & \frac{-y_{12}}{y_{11}} \\ \frac{y_{21}}{y_{11}} & \frac{\Delta y}{y_{11}}\end{bmatrix}$	$\begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22}\end{bmatrix}$	$\begin{bmatrix} \frac{t_{12}}{t_{22}} & \frac{\Delta t}{t_{22}} \\ \frac{-1}{t_{22}} & \frac{t_{21}}{t_{22}}\end{bmatrix}$
t-Parameters	$\begin{bmatrix} \frac{z_{11}}{z_{21}} & \frac{\Delta z}{z_{21}} \\ \frac{1}{z_{21}} & \frac{z_{22}}{z_{21}}\end{bmatrix}$	$\begin{bmatrix} \frac{-y_{22}}{y_{21}} & \frac{-1}{y_{21}} \\ \frac{-\Delta y}{y_{21}} & \frac{-y_{11}}{y_{21}}\end{bmatrix}$	$\begin{bmatrix} \frac{-\Delta h}{h_{21}} & \frac{-h_{11}}{h_{21}} \\ \frac{-h_{22}}{h_{21}} & \frac{-1}{h_{21}}\end{bmatrix}$	$\begin{bmatrix} t_{11} & t_{12} \\ t_{21} & t_{22}\end{bmatrix}$

2-port network equations (continued):

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

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

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

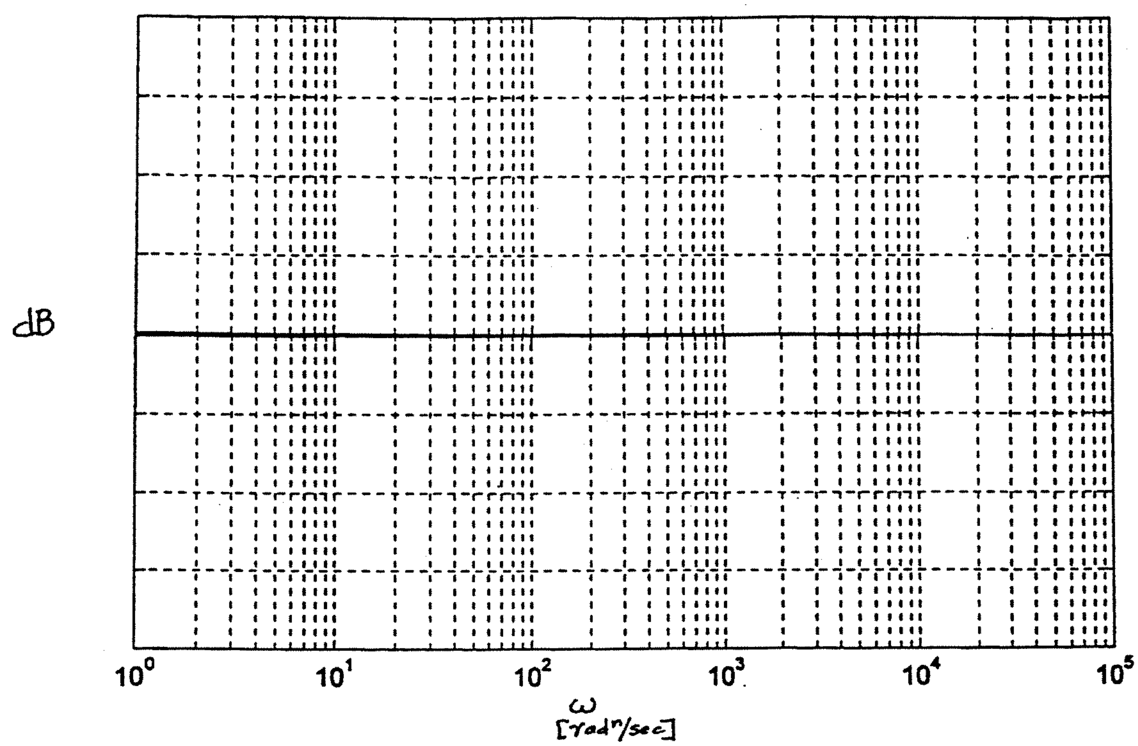
Transmission Line equations:

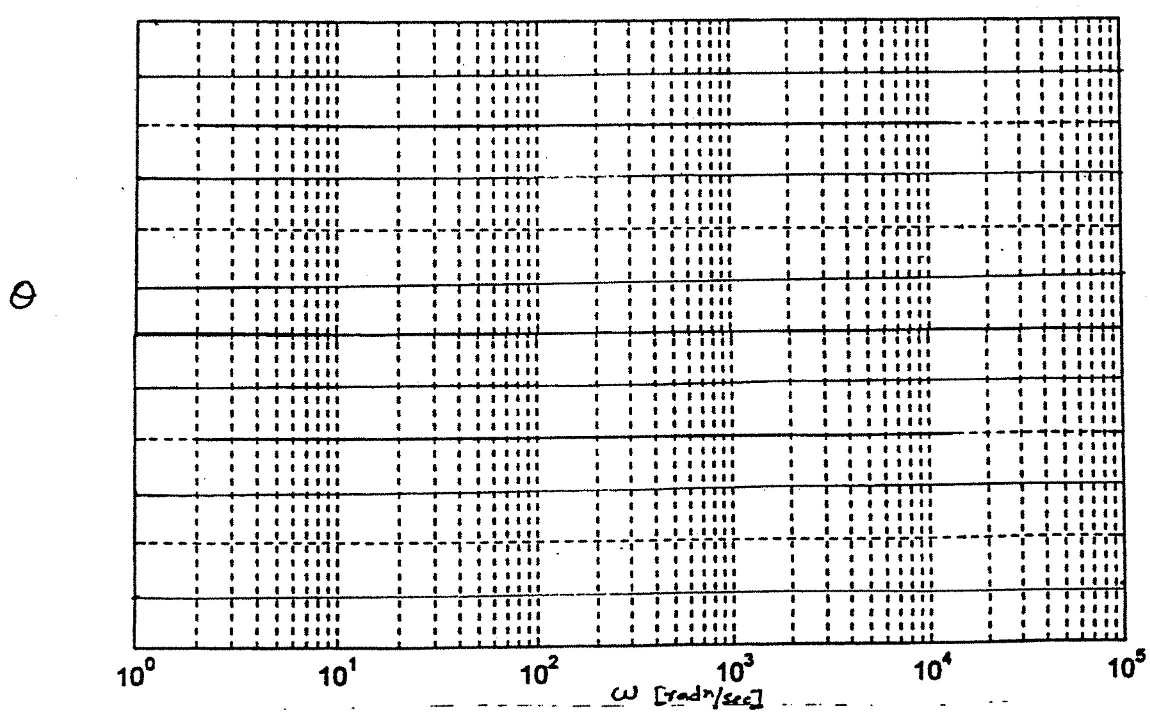
$$Z_c=\sqrt{\frac{R+jwL}{G+jwC}}$$

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

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

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





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