National Examinations, May 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.

(a) write the differential equation involving the current $i(t)$ with E, L, C, and R.

[5]

(b) Solve the differential equation to find the current, $i(t)$ at $t > 0$. for the given initial conditions . **[10]**

(c) Sketch the waveform of $i(t)$. What is the natural frequency of oscillation of the circuit ?

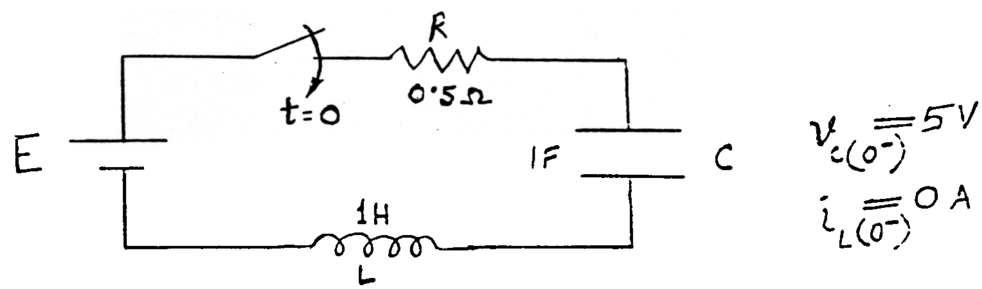


Figure – 1

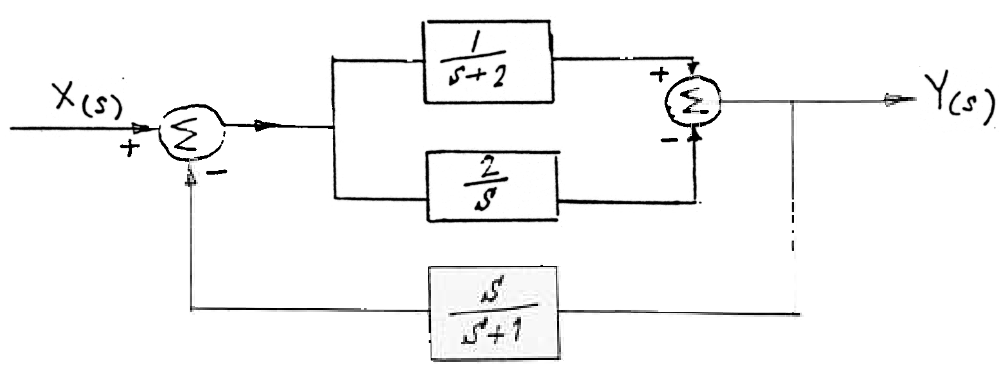
Question 2:

In the block diagram of a control system is shown in figure–2,

(a) calculate the transfer function,

$H(s) = Y(s) / X(s)$ [10]

(b) Calculate the poles and zeros of the system. State whether the system will be stable or unstable.



Figure–2

Question 3:

(a) Figure–3 shows the Amplitude of the Bode plot of a network. From this Bode plot, calculate its transfer function, H(s). 10]

(b) From the H(s) obtained in part (a), draw the phase plot. Use the semilog graph attached in the appendix of this question paper. [10]

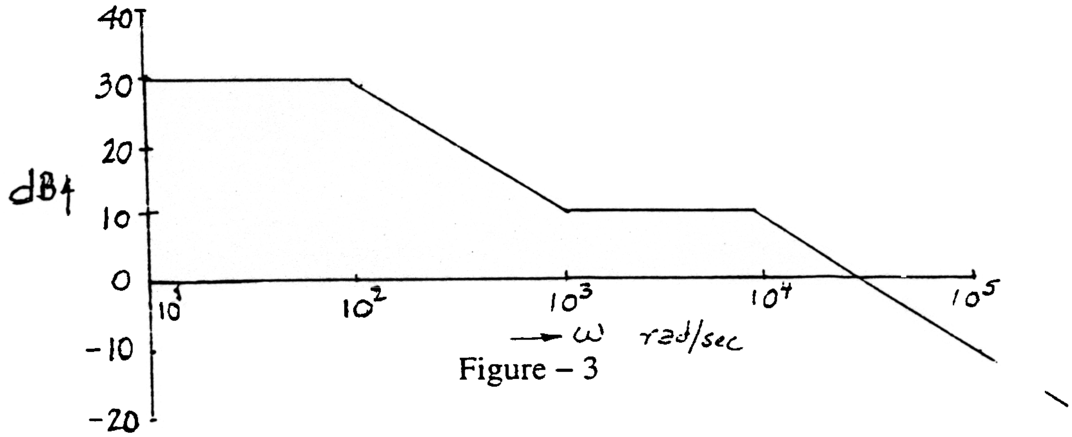


Figure – 3

Question 4:

Figure – 4 shows an active low pass filter.

(a) Derive its transfer function, **H(s)**. From this transfer function, write the expression of its cut off frequency, w_c and gain k of the circuit. [10]

(b) If w_c = 1000 rad/ sec, gain = 5 and C = 0.01 uF, calculate the values of R1 and R2. [10]

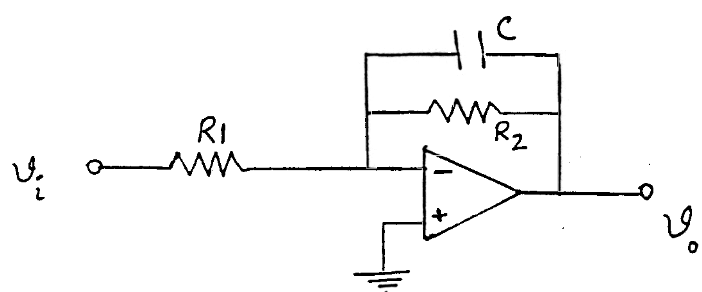


Figure – 4

Question 5:

Calculate the Butterworth low pass transfer function whose 'Brickwall' specifications are shown in figure – 5.

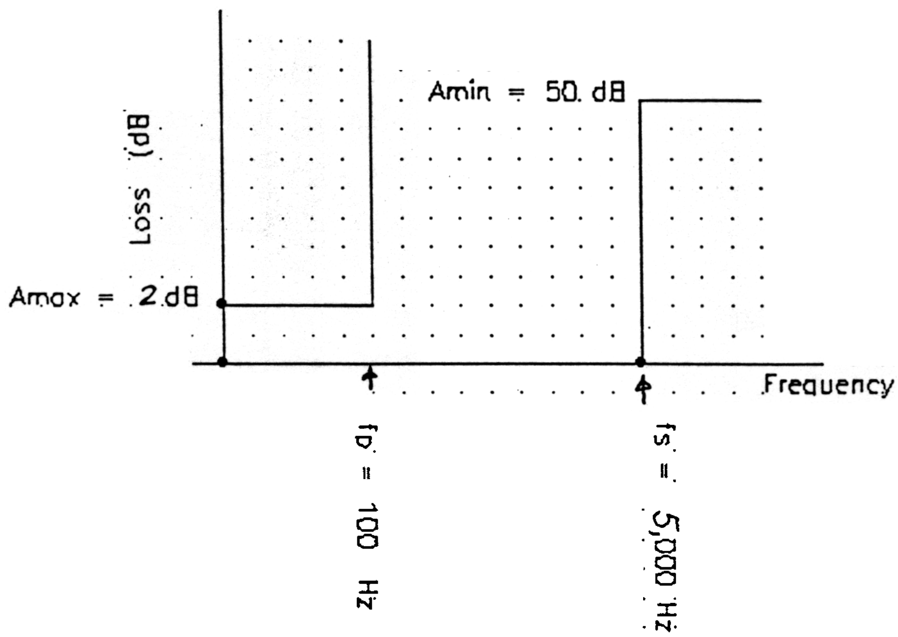


Figure – 5

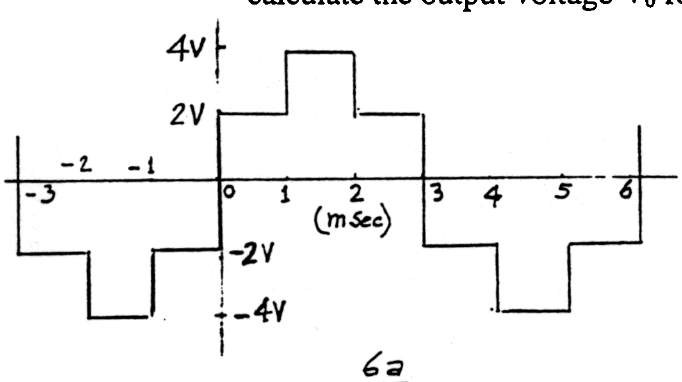
Question 6:

(a) Calculate the Fourier series of the voltage waveform shown in figure– 6a up to the 5th harmonics. **[12]**

(b) If the Fourier series of the voltage shown in figure–6a is

V_{in} = 1.9 sin 2094.4t – 0.64 sin 3141.6t + sin 4188.8t +.......

calculate the output voltage V_o for the 4th harmonic in figure –6b. [8]



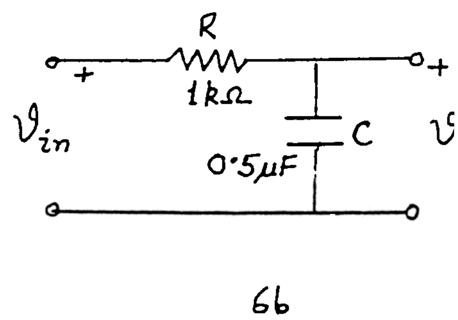


Figure – 6

Question 7:

For the circuit shown in figure – 7, calculate its [z] parameters. [20]

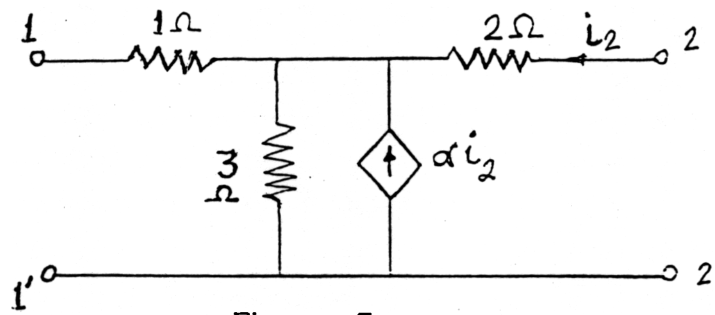


Figure – 7

Question 8:

A microwave transmission line at f = . 5 GHz has $R = 0.5\ \Omega/m$, $L = 10^{-8}$ H/m, $C = 10^{-12}$ F/m and $G = 0.0005$ Mho/m.

Calculate (a) the Characteristic impedance [4]

(b) the Propagation constant [4]

(c) what should be its load impedance to eliminate reflection [4]

If the line is terminated by a load impedance of $Z_L = 100 \angle 10^{0}\ \Omega$, calculate its

(d) Reflection coefficient, and [4]

(e) Standing wave ratio [4]

Appendix

Some useful **Laplace Transforms:**

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

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, $a_n = \frac{4}{T}\int_0^{\frac{T}{2}} f(t)\cos nw_0 t\, dt$. *and* $b_n = 0$

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

Filter equations:

Normalized Butterworth Loss Function, L(s)

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

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

2-port network equations:

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

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

$$[Z]=\begin{bmatrix} \frac{A}{C} & \frac{\Delta T}{C} \\ \frac{1}{C} & \frac{D}{C} \end{bmatrix}$$

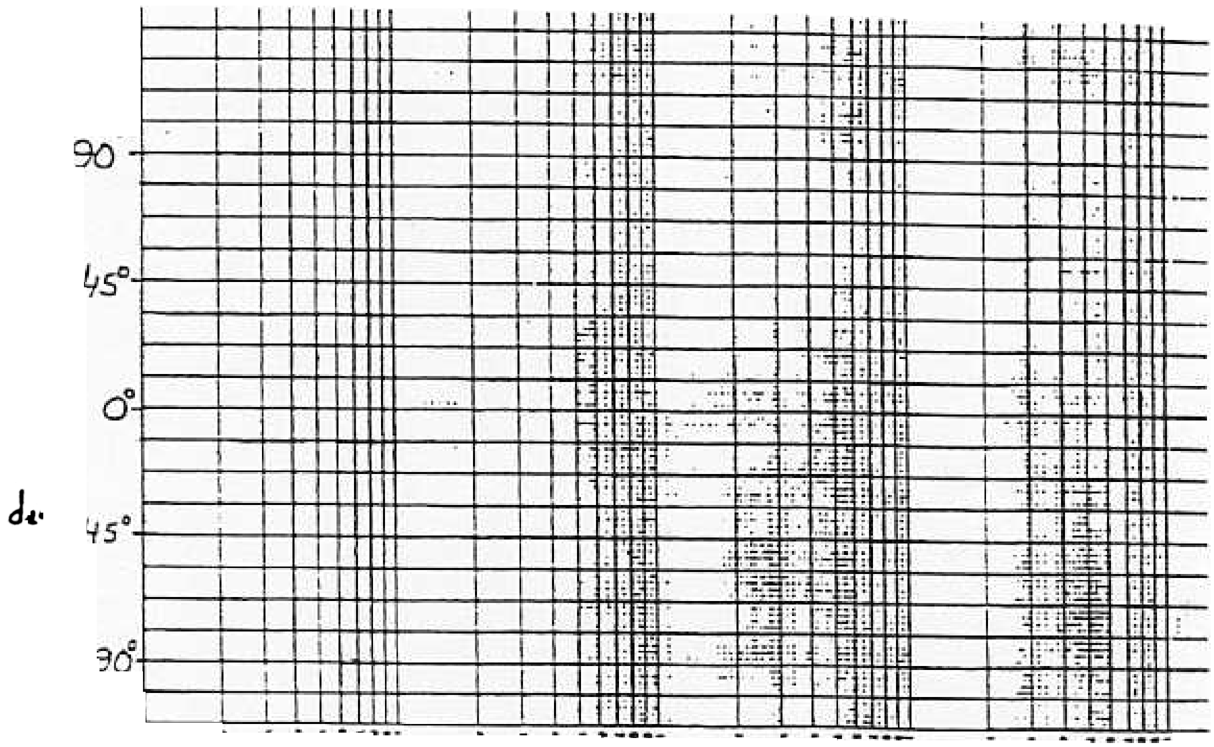
Transmission Line equations:

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

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

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

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



[P as .hi ph f q #4. d tach w h y nsw pape