QA

Indian Institute of Technology, Kharagpur

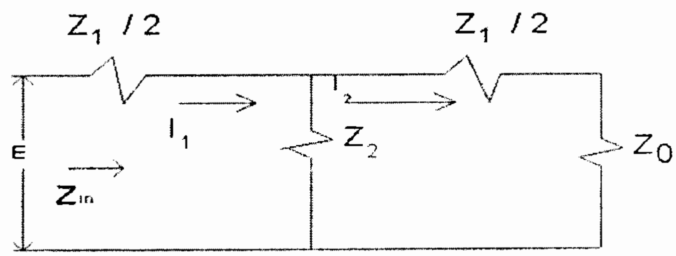
Date FN/AN, Time 3 Hrs, Full marks 45, Deptt E&ECE, No of Students 112, End Autumn Semester Examination, Sub. No. EC21005, Sub. Name Network Theory 2nd Yr. B.Tech, Instruction: Answer All questions, Figures on the margin indicate marks.

Q1. Synthesize a network with only passive R, L and C elements (without transformers) whose driving point impedance is the positive real function

$$Z(s) = \frac{s^5 + 2s^4 + 7s^3 + 4s^2 + 9s + 1}{s^4 + s^3 + 5s^2 + s + 4} \qquad (10)$$

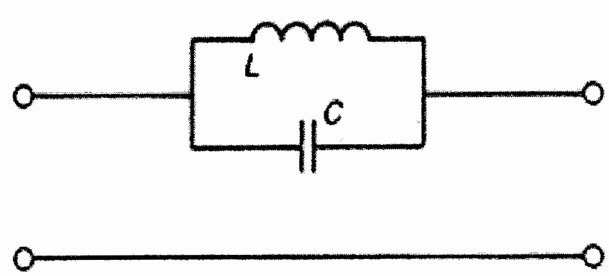
Q2. a) Show that if $\begin{bmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{bmatrix}$ are the Z-parameters of a two port network composed of passive R, L and C elements only then $z_{12} = z_{21}$. Find out the relationship satisfied by the $\begin{bmatrix} A & B \\ C & D \end{bmatrix}$ and h-parameters of such a network. (3+3)

b) For the symmetric T network find the condition when $Z_{in}=Z_0$. What name is this impedance called by?



(3)

Q3. a) Show that the circuit acts as a band reject filter in a power supply line by deriving an expression for its insertion loss. Make suitable assumptions. (4)



b) Design a maximally flat low pass filter having power loss ratio given by $P_{LR} = 1 + k^2\left(\frac{\omega}{\omega_c}\right)^4$ where k and ω_c are constants by the insertion loss method. (6)

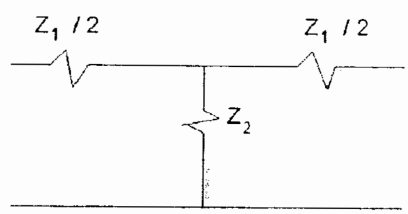
Q4. a) State and prove the Foster's reactance theorem. (3)

b) Show that for a function Z(s) if $\text{Real}(Z(s)) \geq 0$ for $\text{Real}(s) \geq 0$ then Z(s) has no poles in the right half plane and the poles on the $s = j\omega$ axis are simple. (3)

c) Show that the function $\mathrm{Ri}(s) = \dfrac{k\,Z(s) - s\,Z(k)}{k\,Z(k) - s\,Z(s)}$ is a positive real function for positive k if $Z(s)$ is also a positive real function with no poles or zeroes anywhere along the $j\omega$ axis including $s = 0$ or ∞. Show also that the degree of the numerator or denominator polynomial of $\mathrm{Ri}(s)$ is not higher than those of $Z(s)$. (4)

Q5. a) Show that for the two port network below the propagation constant γ is given by

$$\gamma = \log_e\left[1 + \frac{Z_1}{2Z_2} + \sqrt{\frac{Z_1}{Z_2} + \left(\frac{Z_1}{2Z_2}\right)^2}\right]$$ where Z_1 and Z_2 are not necessarily resistive. Show that an expression for $\sinh(\gamma/2)$ in terms of Z_1 and Z_2 is $\sqrt{\dfrac{Z_1}{4Z_2}}$. Put $\gamma = \alpha + j\beta$ in $\sinh(\gamma/2)$ and assume Z_1 and Z_2 are reactive and find the values of α and β in terms of Z_1 and Z_2 both in the pass band and as well as in the stop band. What is α commonly known as? (1+1+2+1)



b) Using the analysis above discuss the pass band and stop band characteristics of a constant k high pass filter (symmetric T). (1)