Exam in TSEI10, Filter

Time: 2013-03-14, 08:00-12:00

Place: TER2

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Aid: Tables and Formulas for Analog and Digital Filters; Calculator; Physics Handbook for Science and Engineering

Instructions: Maximum 60 points where 25, 36, and 48 points are needed to, respectively get 3, 4, and 5. For each problem, motivate your answer to get the maximum number of points.

1. A bound on the deviation, in attenuation, for a doubly resistively terminated LC filter because of the element errors is given as

$$\Delta A(\omega) \leq 8.69\varepsilon \frac{|\rho(j\omega)|}{|H(j\omega)|^2} \omega \tau_g(\omega).$$

Here, $\varepsilon = \frac{\Delta L}{L} = \frac{\Delta C}{C}$ is the tolerance of the inductors and capacitors where $\tau_g(\omega)$ stands for the group delay. Furthremore, $\rho(j\omega)$ is the reflection function. What options does a designer have to reduce $\Delta A(\omega)$? Explain four of them. **(10 p)**

2. Assume two filters $H_1(s) = \frac{s}{s^2+24s+169}$ and $H_2(s) = -\frac{s}{s^2+10s+169}$. Determine the poles and zeros of the overall system if these two filters are: **(10 p)**

   (a) Cacsaded with each other.

   (b) Parallel connected with each other.

3. Assume that a frequency response is represented as

$$H(j\omega) = \frac{a + bj\omega}{c + dj\omega}, \quad a \neq 0, \quad b \neq 0, \quad c \neq 0, \quad d \neq 0.$$

Determine the attenuation function, the phase function, the group delay, and the phase delay. **(10 p)**

4. Assume a two-port with the incident and reflected voltage waves x and y where the input currents and voltages are, respectively, represented with I and V. For ports 1 and 2, we have

$$\begin{bmatrix} x_1 \\ y_1 \end{bmatrix} = P \begin{bmatrix} V_1 \\ I_1 \end{bmatrix}, \quad \begin{bmatrix} x_2 \\ y_2 \end{bmatrix} = Q \begin{bmatrix} V_2 \\ I_2 \end{bmatrix}.$$

If the transmission matrix T is defined as

$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = T \begin{bmatrix} V_2 \\ I_2 \end{bmatrix},$$

Determine the wave transmission matrix F where

$$\begin{bmatrix} x_1 \\ y_1 \end{bmatrix} = F \begin{bmatrix} x_2 \\ y_2 \end{bmatrix}.$$

As you can see, the wave variables x and y are linear combinations of the input currents and voltages. **(10 p)**

5. We want to realize a fifth-order Cauer filter with $\rho = 15\%$, $A_{min} = 45$ dB, $\omega_c = 5.5$ Mrad/s, and $\omega_s = 3.5$ Mrad/s.

   (a) At each stage of the design procedure, what are the values of the poles and zeros? **(4 p)**

   (b) At each stage of the design procedure, what are the values of circuit elements if a T ladder is used? **(4 p)**

   (c) Suggest a suitable grouping of the poles and zeros. **(2 p)**

6. How can we simulate an inductor using a properly loaded generalized immitance converter (GIC)? Determine the parameters of the GIC and its load. Why do we prefer to simulate inductors rather than directly implementing them? **(10 p)**