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Circuit and System Analysis
HW-I

1. Given the system

$$\frac{d}{dt}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(t), \quad \begin{bmatrix} x_1(0) \\ x_2(0) \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$$

find (a) the fundamental matrix,
(b) state transition matrix,
(c) zero-input response,
(d) zero-state response,
(e) $\lim_{t\to\infty} x_1(t) = ?$.
(f) Use MATLAB or similar program and confirm your results.

2. Given the system

$$\frac{d}{dt}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 1 & -1 \\ 6 & -2 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} e, \quad y = \begin{bmatrix} 1 & -1 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

(a) Find $H(jw) = Y(jw)/E(jw)$.
(b) Draw $|H(jw)|$.

DP 10-6 The input to the circuit shown in Figure DP 10-6 is the voltage source voltage

$$v_s(t) = 10\cos(1000t)\ \text{V}$$

The output is the steady-state capacitor voltage

$$v_o(t) = A\cos(1000t + \theta)\ \text{V}$$

(a) Specify values for R and C such that $\theta = -30°$. Determine the resulting value of A.
(b) Specify values for R and C such that $A = 5$ V. Determine the resulting values of θ.
(c) Is it possible to specify values for R and C such that $A = 4$ and $\theta = -60°$? (If not, justify your answer. If so, specify R and C.)
(d) Is it possible to specify values of R and C such that $A = 7.07$ V and $\theta = -45°$? (If not, justify your answer. If so, specify R and C.)

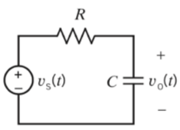

Figure DP 10-6

DP 10-4 Show that it is not possible to design the circuit shown in Figure DP 10-4 to produce the specified output voltage $v_o(t) = 2.5\cos(40t - 14°)$ when provided with the input voltage $v_i(t) = 8\cos(40t)$ V.

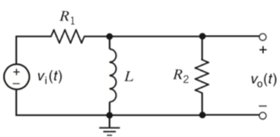

Figure DP 10-4

DP 11-3

(a) Determine the load impedance $\mathbf{Z}_{ab}$ that will absorb maximum power if it is connected to terminals a–b of the circuit shown in Figure DP 11-3.
(b) Determine the maximum power absorbed by this load.
(c) Determine a model of the load and indicate the element values.

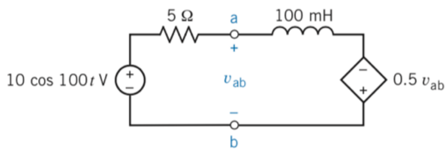

Figure DP 11-3

DP 11-1 A 100-kW induction motor, shown in Figure DP 11-1, is receiving 100 kW at 0.8 power factor lagging. Determine the additional apparent power in kVA that is made available by improving the power factor to (a) 0.95 lagging and (b) 1.0. (c) Find the required reactive power in kVAR provided by a set of parallel capacitors for parts (a) and (b). (d) Determine the ratio of kVA released to the kVAR of capacitors required for parts (a) and (b) alone. Set up a table, recording the results of this problem for the two values of power factor attained.

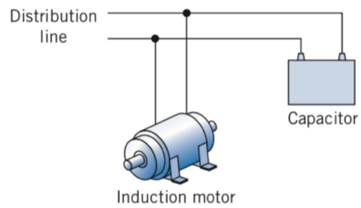

Figure DP 11-1 Induction motor with parallel capacitor.

DP 11-5 An amplifier in a short-wave radio operates at 100 kHz. The load $\mathbf{Z}_2$ is connected to a source through an ideal transformer, as shown in Figure DP 11-5. The load is a series connection of a 10-Ω resistance and a 10-μH inductance. The $\mathbf{Z}_s$ consists of a 1-Ω resistance and a 1-μH inductance.

(a) Select an integer n to maximize the energy delivered to the load. Calculate $\mathbf{I}_2$ and the energy to the load.
(b) Add a capacitance C in series with $\mathbf{Z}_2$ to improve the energy delivered to the load.

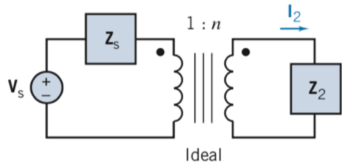

Figure DP 11-5