

Electronic Circuits: Final Examination

10:20~12:00, 1/13/2006

1. (14%) Suppose a feedback resistor R_F is connected from the upper input terminal to the upper output terminal of the amplifier circuit in Fig. 1. Find $R_i' = v_{in} / i_{in}$ and $A_v = v_{out} / v_s$ (expressed as a function of other parameters).

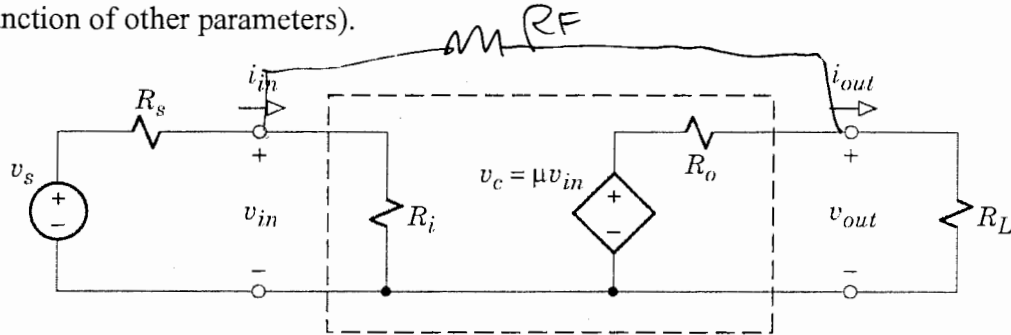


Fig. 1

2. (16%) Let $R = 3\Omega$ and $i_s = 4A$ in Fig. 2. Use node analysis to calculate v_1, v_2, i_1 , and i_2 .

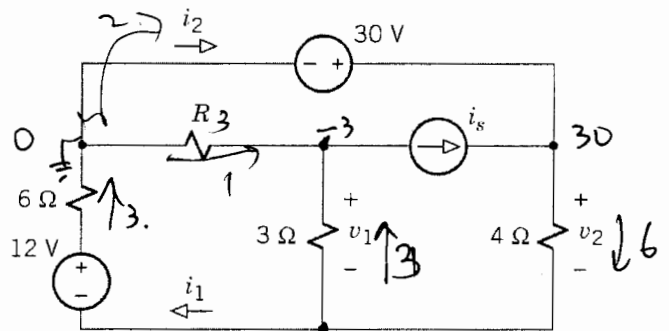


Fig. 2

3. Consider the circuit in Fig. 3.

(a) (10%) Derive the parameters a, b, c , and d, e, f , in terms of C, R, L :

$$\begin{cases} i_L'' + ai_L' + bi_L = ci_s \\ v_C'' + dv_C' + ev_C = fi_s \end{cases}$$

$$\begin{aligned} & -2k_1 e^{-2t} \cos 4t & -2k_2 e^{-2t} \sin 4t \\ & -4k_1 e^{-2t} \sin 4t & 4k_2 e^{-2t} \cos 4t \end{aligned}$$

(b) (10%) Find the step response of $i_L(t)$ when $i_s = 3u(t)$, $C = \frac{1}{40}F$, $R = 10\Omega$, and $L = 2H$.

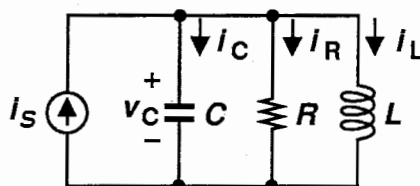


Fig. 3

NOTE: There are problems in the back.

$$\begin{aligned} \Delta &= 12 - 16 = -4 \\ \Delta_1 &= -168 \\ \Delta_2 &= 336 \end{aligned}$$

$$\begin{aligned} & (x+2)^2 + 16 \\ & i_{V2} = 6 \\ & v_1 = -3 \\ & -224i \end{aligned}$$

4. (5%) Consider the circuit in Fig. 4, and find the transfer function of $\frac{V_{out}}{V_{in}}$

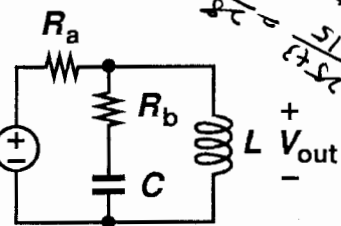


Fig. 4

5. (10%) Draw the asymptotic Bode Plot (both the gain and phase) of $H(s) = \frac{8000s}{(s+10)(s+40)}$

6. (20%) Consider a circuit described by $\frac{d^2i}{dt^2} + 4\frac{di}{dt} + 3i = x$. Find the complete response $i(t)$ for $t > 0$, when $x(t) = 5$ for $t < 0$, and $x(t) = \sin t$ for $t > 0$. Please feel free to use \times , $||$, $\sqrt{}$ and \tan^{-1} wherever appropriate.

7. (15%) Given $F(s) = \frac{2s^2 + 5}{(s-3)(s^2 + 4s + 40)}$, find the corresponding time-domain function $f(t)$

via inverse Laplace transform. Also find $f(\infty)$ using the final-value theorem, or explain why the theorem is not applicable. Please feel free to use \times , $||$, $\sqrt{}$ and \tan^{-1} wherever appropriate.

Handwritten calculations for problem 7:

$$F(s) = \frac{2s^2 + 5}{(s-3)(s^2 + 4s + 40)}$$

Partial fraction decomposition:

$$\frac{2s^2 + 5}{(s-3)(s^2 + 4s + 40)} = \frac{A}{s-3} + \frac{Bs+C}{s^2 + 4s + 40}$$

Using the method of equating coefficients:

$$2s^2 + 5 = A(s^2 + 4s + 40) + (Bs+C)(s-3)$$

$$2s^2 + 5 = As^2 + 4As + 40A + Bs^2 - 3Bs + Cs - 3C$$

$$2s^2 + 5 = (A+B)s^2 + (4A-3B)s + (40A-3C)$$

Equating coefficients:

$$\begin{cases} A+B = 2 \\ 4A-3B = 0 \\ 40A-3C = 5 \end{cases}$$

Solving the system:

$$B = 2-A$$

$$4A - 3(2-A) = 0 \Rightarrow 4A - 6 + 3A = 0 \Rightarrow 7A = 6 \Rightarrow A = \frac{6}{7}$$

$$B = 2 - \frac{6}{7} = \frac{8}{7}$$

$$40\left(\frac{6}{7}\right) - 3C = 5 \Rightarrow \frac{240}{7} - 3C = 5 \Rightarrow 3C = \frac{240}{7} - 5 = \frac{240-35}{7} = \frac{205}{7} \Rightarrow C = \frac{205}{21}$$

Final result:

$$f(t) = \frac{6}{7}e^{3t} + \frac{8}{7}\cos t + \frac{205}{21}\sin t$$