

GEORGIA INSTITUTE OF TECHNOLOGY  
School of Electrical and Computer Engineering

Course ECE 2040

Circuit Analysis

Assigned: February 16, 2001

Due: February 23, 2001

## Problem Set #6

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**Reading:** Read the following sections from the class notes:

Chapter 4, Sections 4.1–4.3

Chapter 5, Sections 5.2–5.4

**Reading:** Some of same topics are discussed in Dorf and Svoboda:

Chapter 6, Sections 6.4–6.6; (operational amplifiers)

Chapter 14, Sections 14.3 (Laplace transform definitions)

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**Announcement:** Quiz #2 will be held during the class hour on Monday, February 19, 2000. It will be a closed book test, although calculators are permitted. It will cover problem sets 3–5.

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**Problem 6.1:** Express  $v_{out}(t)$  in terms of  $v_{in}(t)$  for the circuit in Figure 1.

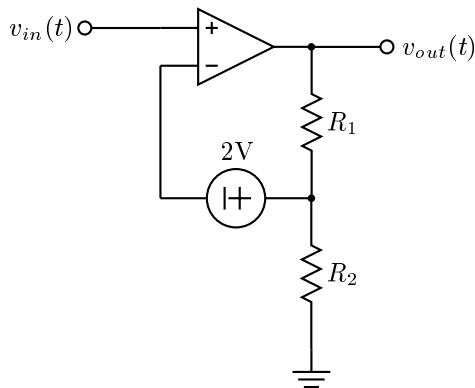


Figure 1: Circuit for Problem 6.1.

**Problem 6.2:** Determine the output voltage  $v_{out}(t)$  in terms of the input voltage  $v_{in}(t)$  for the circuit in Figure 2.

**Problem 6.3:** The circuit in Figure 3 is a current amplifier. Compute the value of the current gain,  $G$ :

$$G = \frac{i_L(t)}{i_s(t)}$$

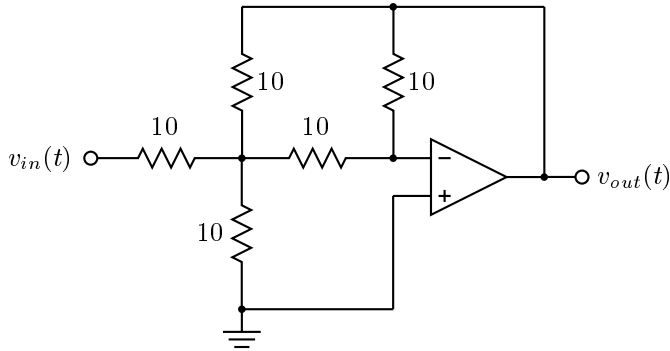


Figure 2: Circuit for Problem 6.2.

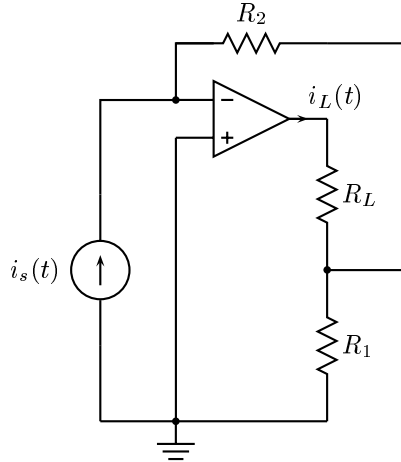
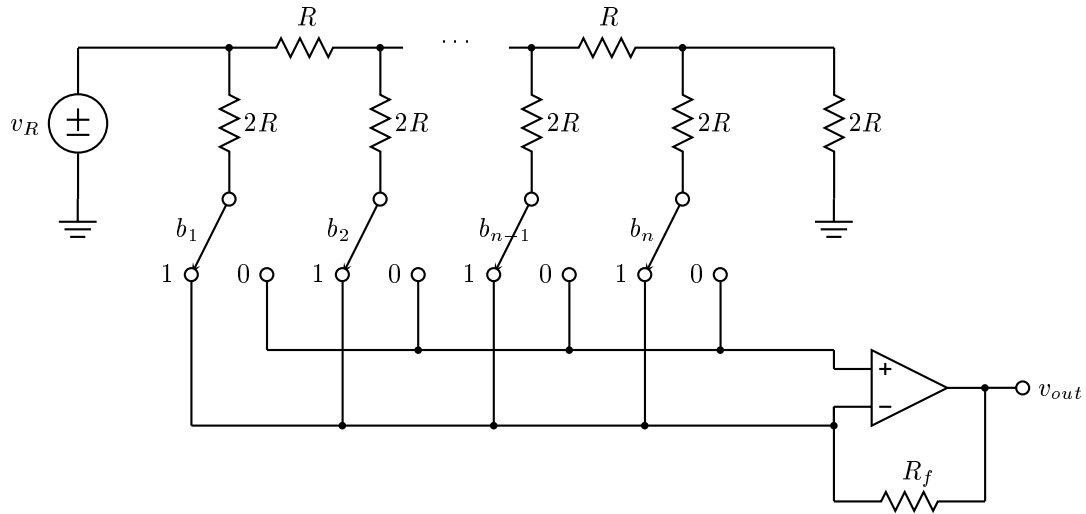


Figure 3: Circuit for Problem 6.3.

**Problem 6.4:** The circuit shown in the next figure is called an inverted  $R - 2R$  ladder digital-to-analog converter (DAC). The input to this circuit is a binary code represented by  $b_1, b_2, \dots, b_n$ , where  $b_i$  is either 1 or 0. Each switch shown in the figure is controlled by one of the bits in the binary code. If  $b_i = 1$ , that switch will be in the '1' position; if  $b_i = 0$ , that switch will be in the '0' position. Depending on the position of the switch, each current  $i_k$  is diverted either to true ground (adding to the + terminal of the opamp) or to the virtual ground (adding to the - terminal.)

- If  $i$  is the current flowing out of the voltage source, show that  $i = v_R/R$  regardless of the digital input code.
- Show that the output voltage can be expressed as

$$v_{out}(t) = -\frac{R_f}{R} v_R (b_1 2^{-1} + b_2 2^{-2} + \dots + b_{n-1} 2^{-n+1} + b_n 2^{-n})$$



**Problem 6.5:** Express each of the following as exponentially weighted sinusoidal time functions of the form  $x(t) = Ae^{\sigma t} \cos(\omega t + \phi)$ .

(a)  $x_a(t) = \frac{1+j}{2}e^{(-2+j3)t} + \frac{1-j}{2}e^{(-2-j3)t}$ .

(b)  $x_b(t) = \sqrt{3}e^{-t} \cos(2t) - e^{-t} \sin(2t)$ .

(c)  $x_c(t) = \frac{j\omega_0}{1+j\omega_0}e^{j\omega_0 t} - \frac{j\omega_0}{1-j\omega_0}e^{-j\omega_0 t}$ .

**Problem 6.6:** Determine the Laplace transforms of the following time waveforms.

(a)  $x_a(t) = \begin{cases} 1, & 0 \leq t \leq T \\ 0, & \text{otherwise} \end{cases}$

(b)  $x_b(t) = t^2 e^{-3t}, \quad t > 0$

(c)  $x_c(t) = e^{-4t} \sin 5t, \quad t > 0$

(d)  $x_d(t) = t, \quad t > 0$