

MAE140 - Linear Circuits - Fall 2018
Midterm, November 13th

Instructions

1. This exam is open book. You may use whatever written materials you choose, including your class notes and textbook. You may use a hand calculator with no communication capabilities.
2. You have 70 minutes.
3. Write your answers on your "Blue Book".
4. Do not forget to write your name, student number, and instructor.
5. This exam has 3 questions, for a total of 27 points.

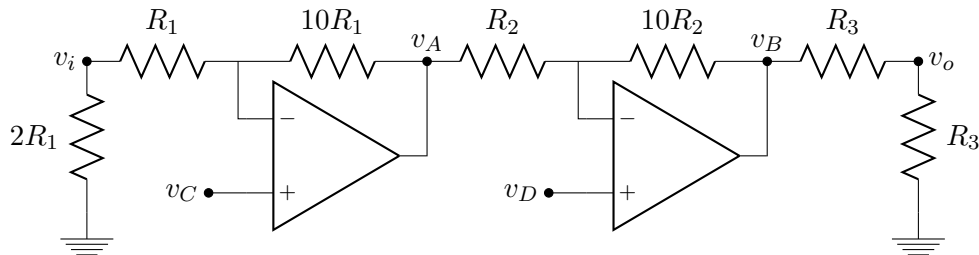


Figure 1: Circuit for Questions 1 and 2

1. Gain Analysis

Connect v_C and v_D to the ground in the circuit in Fig. 1 and answer the following questions:

- (a) (3 points) Calculate the gains: v_i to v_A , v_A to v_B , v_B to v_o .
- (b) (1 point) Calculate the gain: v_i to v_o .
- (c) (4 points) Calculate the gain v_s to v_o if a circuit with Thevenin voltage v_s and equivalent resistance $2R_1/3$ is connected to the input v_i .
- (d) (1 point) If a circuit is to be connected to v_i as in part (c), show how you could add an opAmp circuit before connecting the circuit to v_i to make the gain from v_s to v_o equal to the gain from v_i to v_o .

2. Voltage Offset

Let $v_C = v_D = 1V$ and answer the following questions regarding the opAmp circuit in Fig. 1:

- (a) (3 points) Show that $v_A = 11 - 10v_i$, $v_B = 100v_i - 99$, $v_o = 50v_i - 49.5$.
- (b) (3 points) Let the signal $v_i = 1 + v_r$ in which $-0.01V \leq v_r \leq 0.01V$. Calculate the corresponding range for the signal v_o and the the gain from v_r to v_o .
- (c) (2 points) Calculate the largest possible value of $-v_{CC}$ and the smallest possible value of $+v_{CC}$ so that the voltages v_A and v_B do not saturate for a signal $v_i = 1 + v_r$ as in part (b).
- (d) (1 point) Let $+v_{CC} = 2V$ and $-v_{CC} = 0V$ and design an additional circuit with access only to these voltages that when connected to the circuit in Fig. 1 is such that $v_C = v_D = 1V$.

3. OpAmp Design

Design an opAmp circuit that implements the following operations $v_o = 2(v_1 - v_2) + v_3$

- (a) (3 points) Using any number of opAmps.
- (b) (3 points) Using at most two opAmps. *Not necessary if part (a) has two opAmps or less*
- (c) (3 points) Using at most one opAmp. *Not necessary if part (b) has one opAmp*