

# 國立清華大學 100 學年度碩士班入學考試試題

系所班組別：動力機械工程學系乙組(電控組)

考試科目 (代碼)：電路學及電子學 (1102)

共 5 頁，第 1 頁 \*請在【答案卷、卡】作答

**Notice:** To have full credits, you should describe your approximation and assumptions, write down every essential equation, and give properly explanation in solving problems.

1. Choose the one alternative that best completes the statement or answers the question. One point for each correct answer. (10 pts)
  - (a) A network has 10 branches and 8 nodes, then how many independent loops would it be?  
A) 2      B) 3      C) 17      D) 18      E) not enough information.
  - (b) The Wheatstone bridge circuit is widely used to measure:  
A) exact voltages.      B) precise resistances.      C) accurate currents.  
D) precise power.      E) all the these.
  - (c) A resistor with negative resistance, implies that  
A) It will still dissipate power.      B) It can deliver power.  
C) It has a positive voltage drop.      D) It will reduce current flow.      E) none of these.
  - (d) If a circuit element is measured to have  $i = \sin 10t$  and  $v = \cos 10t$ , the element is  
A) a resistor.      B) a capacitor.  
C) an inductor.      D) none of these.      E) all of these.
  - (e) Electrolytic capacitor differ from all other capacitors in construction in that they are:  
A) larger.      B) smaller.  
C) sensitized.      D) polarized.      E) none of these.
  - (f) If a  $22 \mu\text{F}$  and  $100 \mu\text{F}$  capacitor are connected in series with a 15V source, the total capacitance equals \_\_\_\_\_ and the  $22 \mu\text{F}$  capacitor drops \_\_\_\_\_.  
A)  $122 \mu\text{F}$ , 15V.      B)  $18 \mu\text{F}$ , 12.30V.  
C)  $18 \mu\text{F}$ , 2.7V.      D)  $18 \mu\text{F}$ , 15V.      E) none of these.
  - (g) In a series RLC circuit while operating below the resonant frequency, the impedance is:  
A) more capacitive.      B) more inductive.  
C) at minimum.      D) at maximum.      E) none of these.
  - (h) What is the source voltage in a series resonant circuit if  $V_c = 150\text{V}$ ,  $V_L = 100\text{V}$  and  $V_R = 50\text{V}$ ?  
A) 300V.      B) 100V.      C) 70.71V.  
D) 35.35V.      E) none of these.

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共 5 頁，第 2 頁

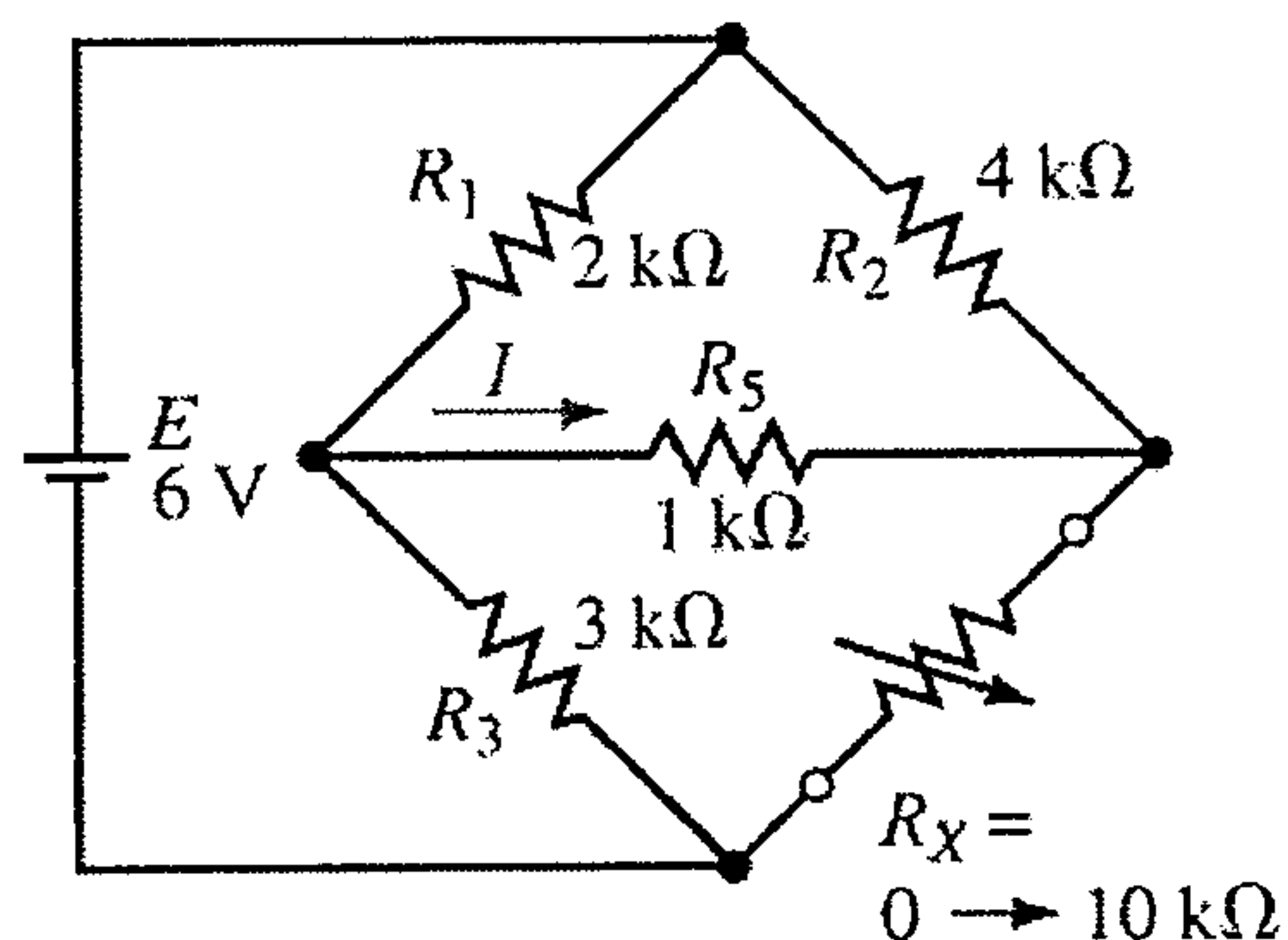
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- (i) What is the bandwidth of a series resonant circuit if the resonant frequency is 14.2 MHz, the inductive reactance is  $2 \text{ k}\Omega$  and the coil's resistance is  $8 \Omega$ ?
- A) 8.8 kHz.                                  B) 1.42 kHz.  
C) 2.84 kHz.                                  D) 5.68 kHz.                                  E) none of these.
- (j) If the true power is 100W and the reactive power is 100 VAR (Ind.), the power factor is:
- A) 0.707 leading.                              B) 0.707 lagging.  
C) 0.5 leading.                                  D) 0.5 lagging.                                  E) none of these.
2. Fill the blanks for the following questions: (10 pts. 1 pt for each blank)
- (a) The characteristics of ideal operational amplifier are (A), zero common-mode gain, (B), and infinite bandwidth.
- (b) Moore's law describes that transistor density of semiconductor chips would be (C) roughly every (D) months.
- (c) Diodes can be combined with resistors to form a (E) circuit that converts an ac voltage into one that is limited to one polarity.
- (d) A (F) forms between two regions if a piece of intrinsic silicon is doped so that half is n-type and the other half is p-type.
- (e) (G) means that a voltage produced from the action of photons in a solar cell.
- (f) The characteristics for Source Follower are high input resistance, (H), (I), and relatively large current gain.
- (g) Field-effect transistors, FETs, are solid-state devices in which an (J) controls the flow of charge carriers through a conducting channel.

3. For the following bridge circuit as shown in Figure 3. (10 pts)

- (a) Determine  $R_x$  to make  $I=0$ .
- (b) If  $R_x$  is  $4 \text{ k}\Omega$ , calculate I.

Figure 3



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共 5 頁，第 3 頁 \*請在【答案卷、卡】作答

4. As shown in Figure 4, the neon light fires when its voltage reaches 60V and turn off when its voltage drops to 30V. Its resistance is  $120\Omega$  when on and infinitively large when off. (10 pts)

(a) For how long is the lamp on each time the capacitor discharges?

(b) What is the time interval between light flashes?

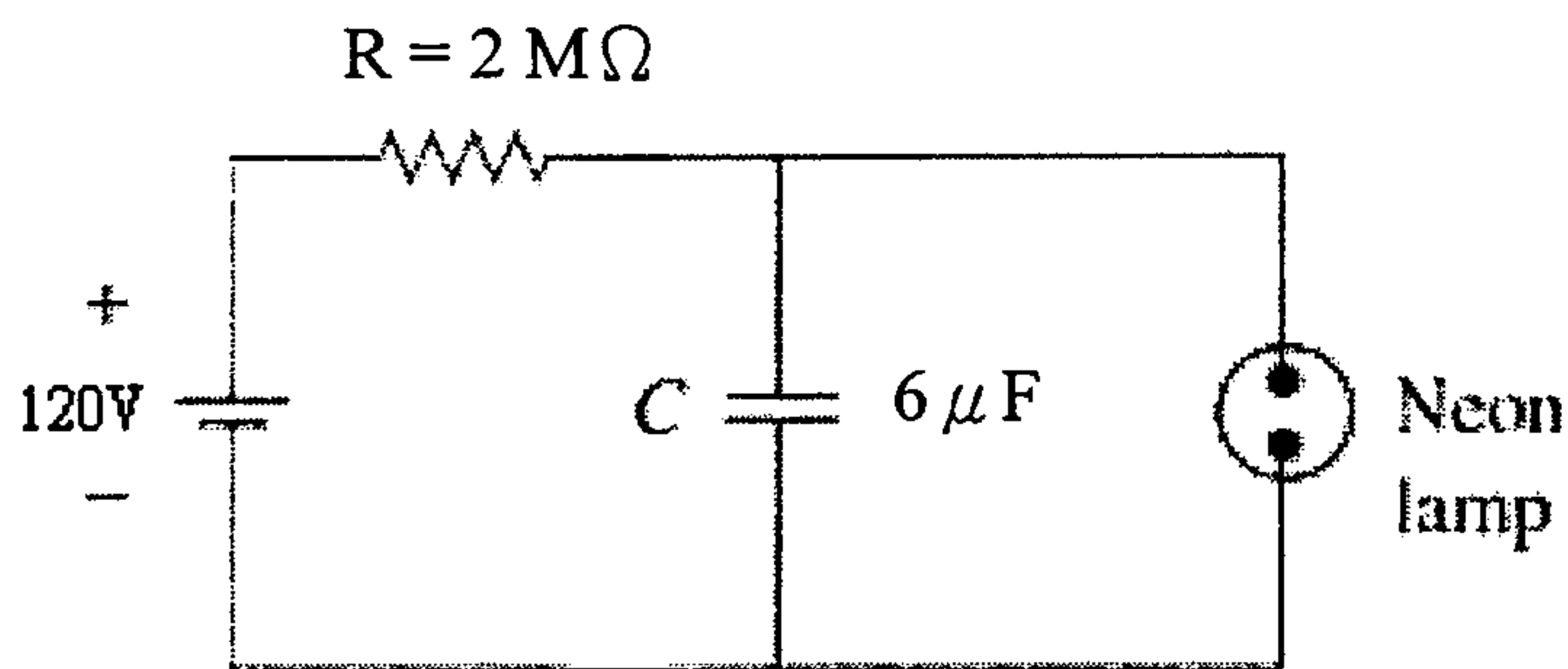


Figure 4

5. A 120-V rms 60-Hz source supplies two loads connected in parallel, as shown in Figure 5. (15 pts)

(a) Find the power factor of the parallel combination.

(b) Calculate the value of the capacitance connected in parallel that will raise the power factor to unity.

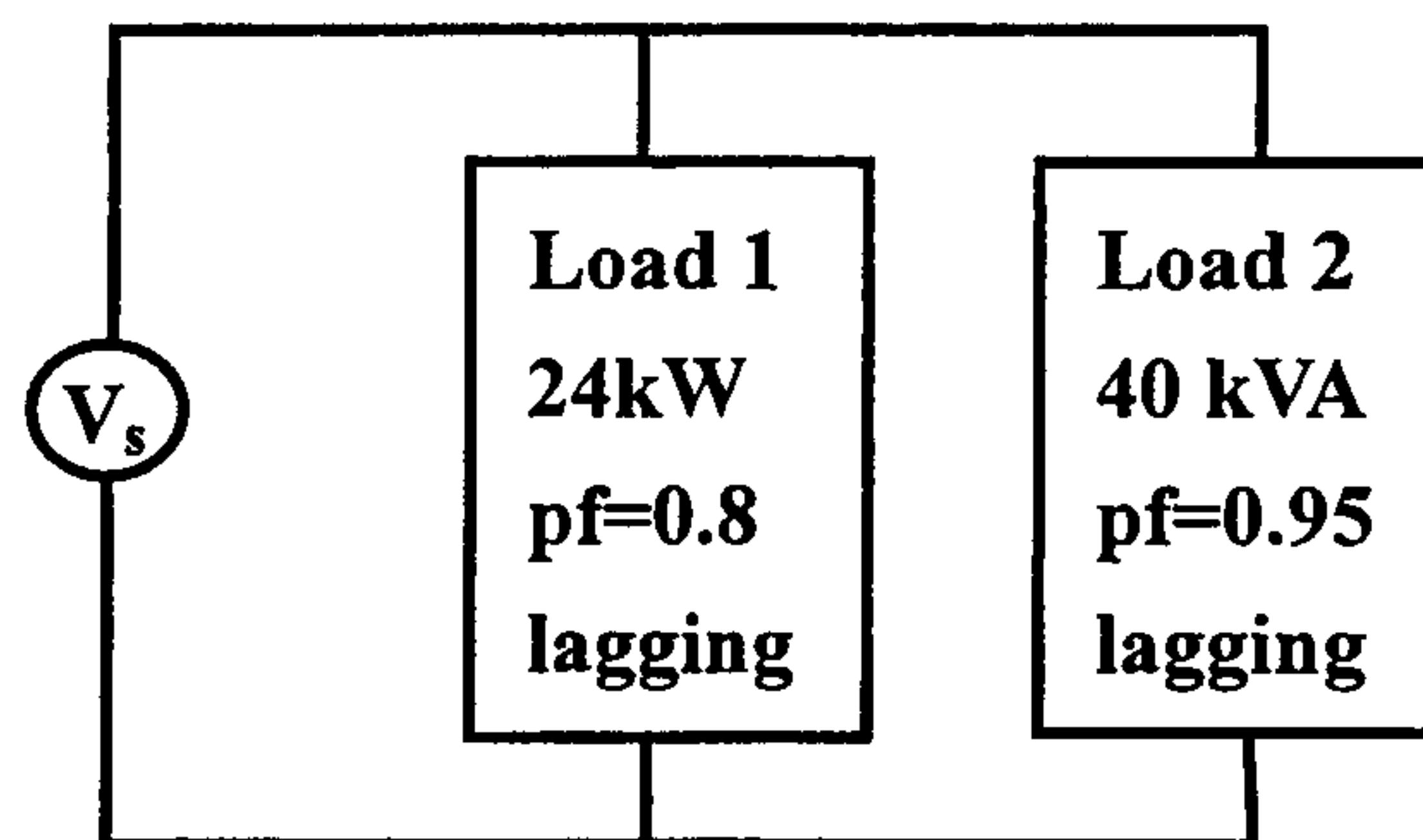


Figure 5

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6. Derive the differential equation for the output  $v_O$  of op-amp circuit shown in Figure 6. (10 pts)

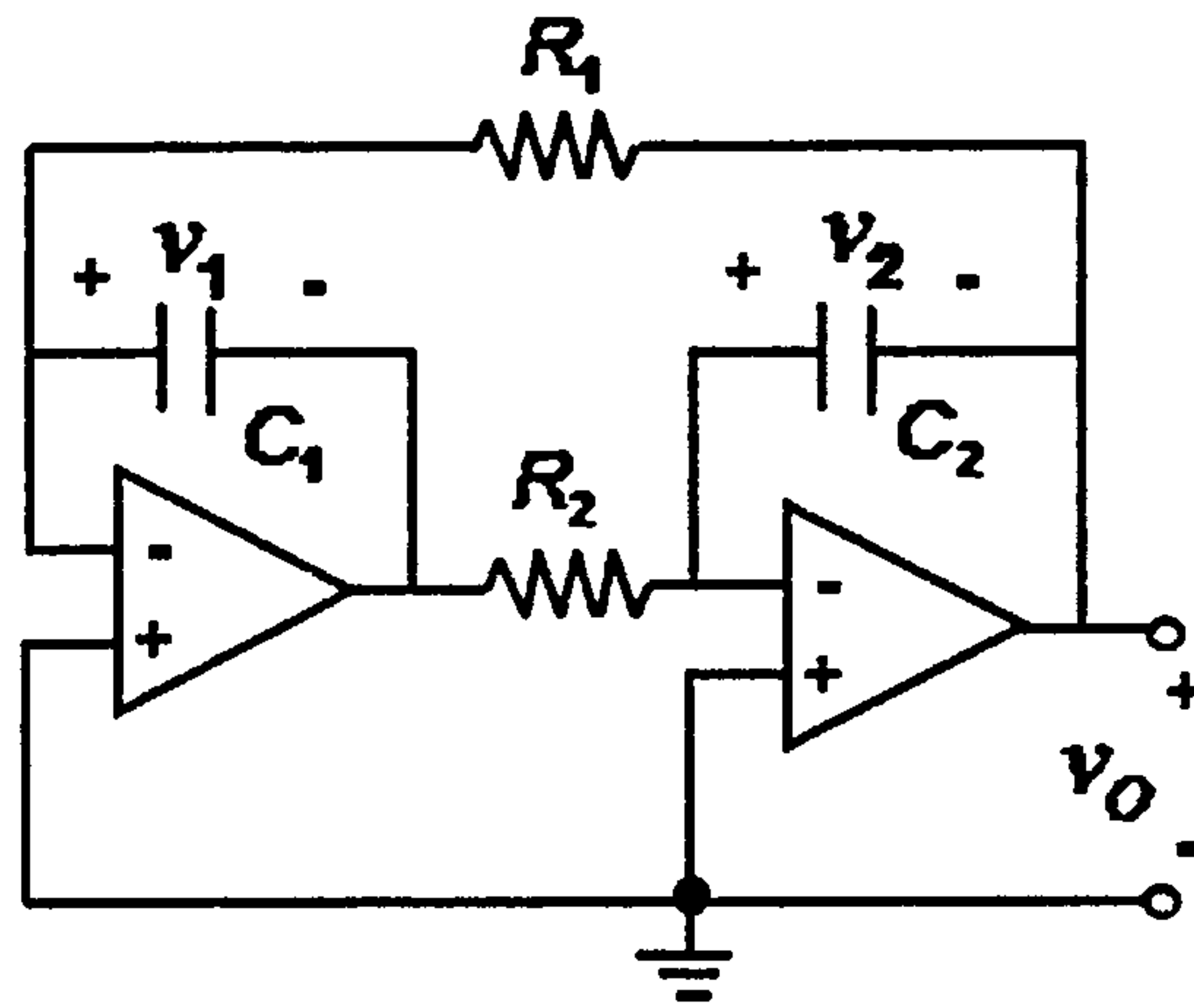


Figure 6

7. The parameters of the transistor in the circuit in Figure 7 are  $\beta = 100$  and Early voltage  $V_A = \infty$ .
- Determine  $R_1$  and  $R_2$  to obtain a bias-stable circuit; that is  $R_1 \parallel R_2 = 0.1(1 + \beta)R_E$ , with the Q-point in the center of the load line,  $R_C = 0.8 \text{ k}\Omega$  and  $R_E = 0.2 \text{ k}\Omega$ . (9 pts)
  - Derive the small-signal voltage gain  $A_v = v_O/v_S$ . (Please DO NOT calculate the voltage gain; only derive the expression.) (6 pts)

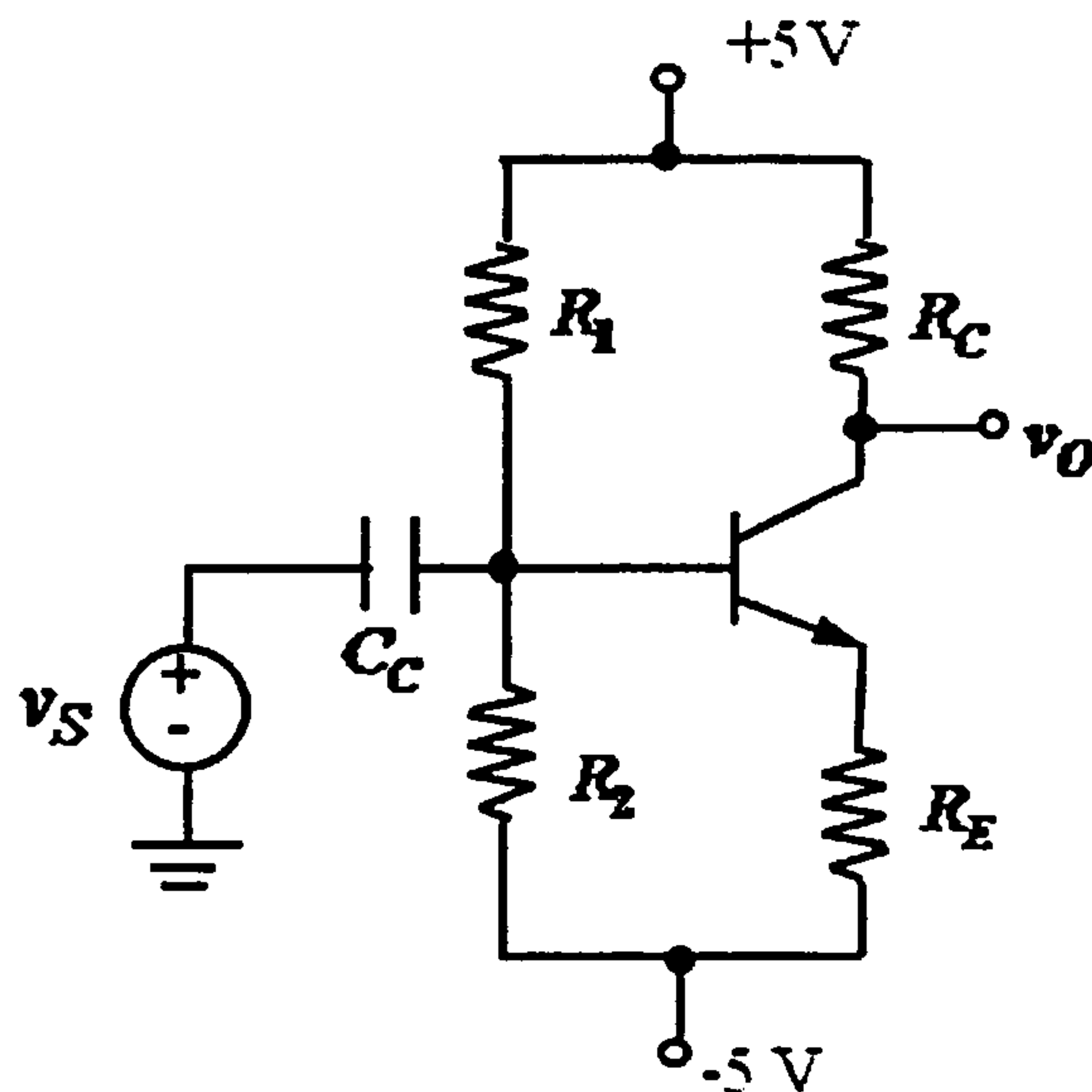


Figure 7



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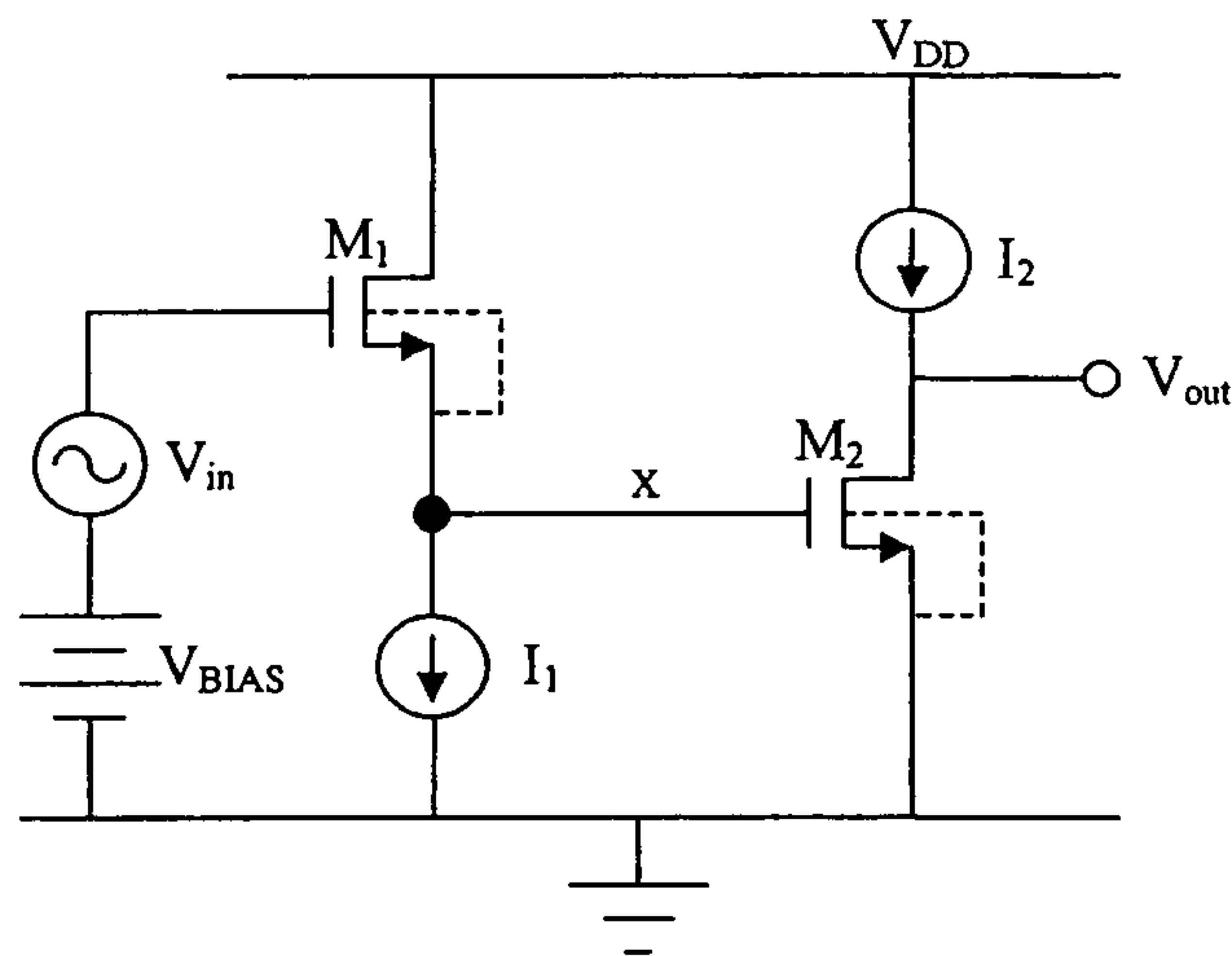
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8. For the circuit shown in Figure 8, assume  $g_{m1} \gg 1/r_{o1}$ . The source and bulk of  $M_1$  are connected.  $M_1, M_2$  are in saturation.
- (a) Write an expression for the small signal gain of entire circuit,  $v_{out}/v_{in}$ . (4 pts)
- (b) Given that  $V_{th} = 1$  V,  $g_{m1} = g_{m2} = 1$  ms,  $I_1 = I_2 = 150$   $\mu$ A. What is the value of  $V_{BIAS}$ ? (Hint: One of the three expressions for transconductance is very useful for this problem.) (6 pts)

Figure 8



9. As shown in Figure 9, all devices are operating in saturation. Ignore all capacitances except  $C_L$ . Body of  $M1, M2$  at ground.  $M1 = M2, M3 = M4 = M5$ .
- (a) Draw the small-signal equivalent model. (4 pts)
- (b) Derive an expression for output voltage gain,  $v_{out}/v_{in}$ . (6 pts)

Figure 9

