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Q1: Fig. 1a shows the cascade connection of a voltage amplifier and a current amplifier. Provide expressions for the open-circuit voltage gain A_{vo} , input resistance R_i , and output resistance R_o of an equivalent voltage amplifier, i.e., Fig. 1b.

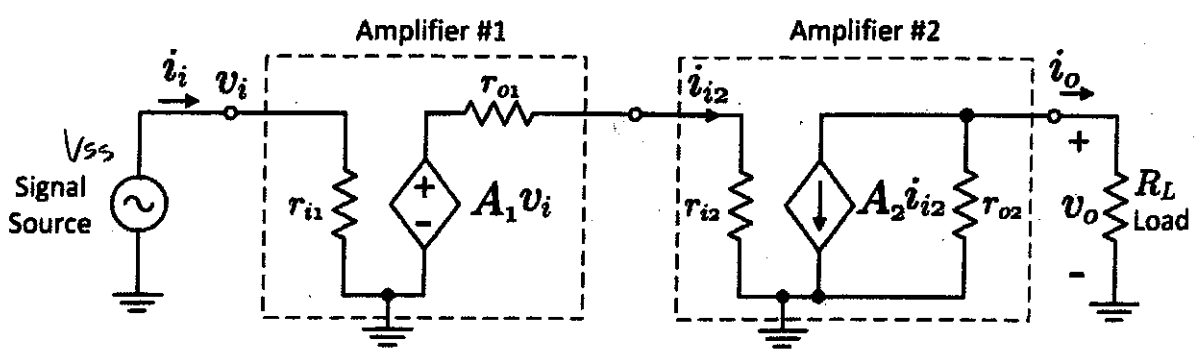


Fig. 1a: cascaded amplifiers of Q1.

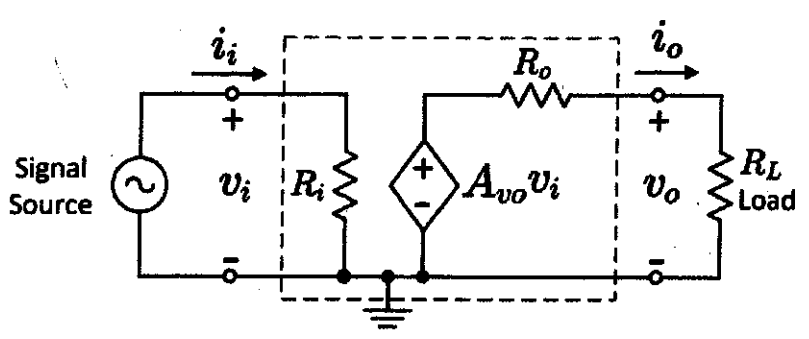
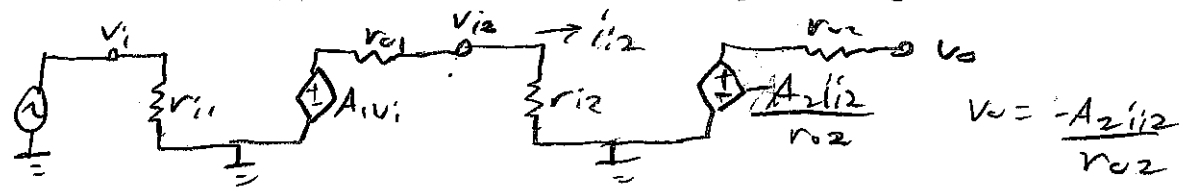


Fig. 1b: voltage amplifier equivalent to the cascaded amplifiers of Fig. 1a.



$$i_{i2} = \frac{A_1 v_i}{r_{o1} + r_{i2}}, \quad v_o = -\frac{A_2 i_{i2} r_{o2}}{r_{o2}}$$

$$v_o = \frac{-A_1 A_2 v_i}{r_{o2}(r_{o1} + r_{i2})}, \quad A_{vo} = \frac{v_o}{v_i} = \frac{-A_1 A_2}{r_{o2}(r_{o1} + r_{i2})} \quad (15)$$

$$R_i = \frac{v_i}{i_i} = \frac{v_i}{i_{i1}} = r_{i1} \quad (9)$$

$$R_o = \frac{v_o}{i_o} = \frac{v_o}{v_o / r_{o2}} = r_{o2} \quad (9)$$

$$R_o = r_{o2} \quad (9)$$

1a

Q2: In the circuit of Fig. 2, the capacitor may be assumed to be very large and the time function of the input signal is $v_s = 5 + 9 \cos(\omega t)$ [V]. Determine the time function of the input voltage v_i and that of the output voltage v_o . The parameters are $R_s = 1.8 \text{ k}\Omega$, $R_1 = 12 \text{ k}\Omega$, $R_2 = 18 \text{ k}\Omega$, and $V_{CC} = 15 \text{ V}$ [hint: regard v_s as the series connection of a dc source $V_s = 5 \text{ V}$ and a sinusoidal source $v_s = 9 \cos(\omega t)$].

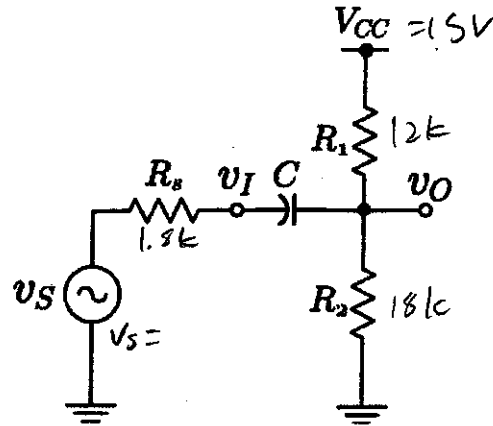
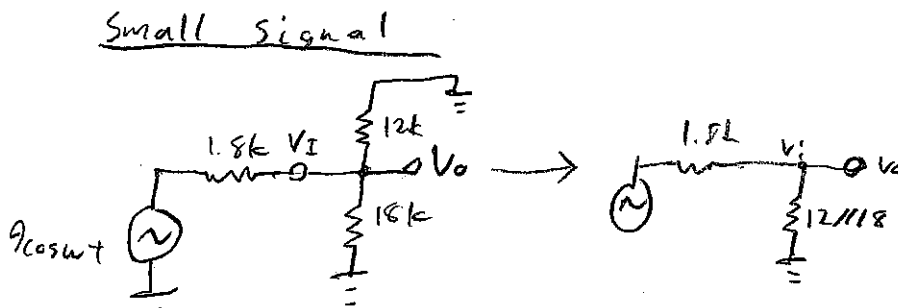
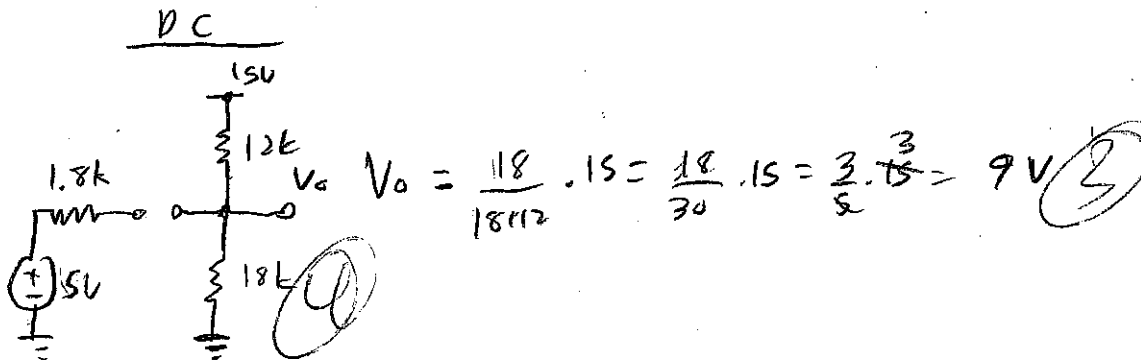


Fig. 2: circuit of Q2.



$$V_s = 9 \text{ V}_p$$

$$V_s = \frac{9}{\sqrt{2}} = 6.364 \text{ V}_{rms}$$

$$V_i = V_o = \frac{12 \parallel 18}{12 \parallel 18 + 1.8} \cdot 6.364$$

$$= \frac{12(18)}{12+18} \cdot 6.364$$

$$= \frac{12(18)}{12+18} \cdot 6.364$$

$$= \frac{36.15}{36.15 + 1.8} \cdot 6.364$$

$$= 6.062 \text{ V}$$

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Q3: In the diode circuit of Fig. 3, the diodes may be assumed to be ideal, $V_x = 10\text{ V}$, $I_x = 4\text{ mA}$, $R_1 = 1\text{ k}\Omega$, and $R_2 = 2\text{ k}\Omega$. Showing all the work, determine the conduction states ("on" or "off") of the diodes, and calculate the voltages V_1 , V_2 , V_3 , and V_4 . Summarize your findings in Table 3.

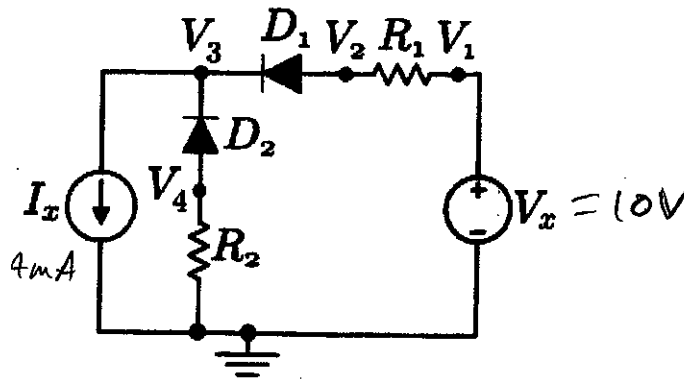
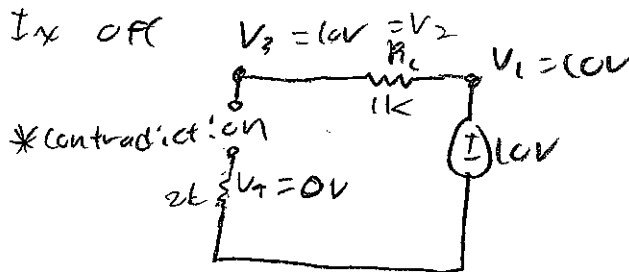
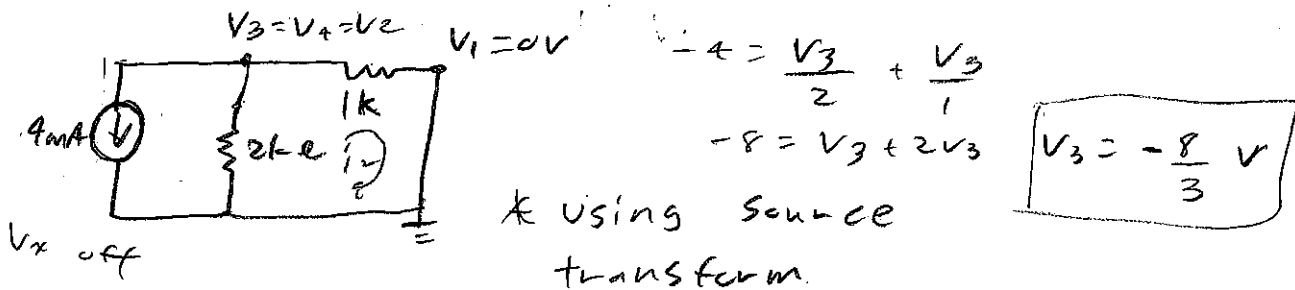


Fig. 3: diode circuit of Q3.

Table 3: results of the circuit of Q3

D_1	D_2	V_1 [V]	V_2 [V]	V_3 [V]	V_4 [V]
on	off	10V	6V	6V	0V

Both on



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If V_x is conducting, D_2 will always be off, but no current flows due to V_x . D_2 will always be off if V_x is conducting.

(14)

Q4: In the Common-Emitter (CE) amplifier of Fig. 4, $R_1 = 68\text{ k}\Omega$, $R_2 = 33\text{ k}\Omega$, $R_3 = 3.9\text{ k}\Omega$, $R_4 = 4.7\text{ k}\Omega$, $R_S = 0.6\text{ k}\Omega$, $R_L = 10\text{ k}\Omega$, $\beta = 200$, $V_{BE} = 0.7\text{ V}$, $V_{CEsat} = 0.3\text{ V}$, and $V_{CC} = +15\text{ V}$. The capacitances may be assumed to be very large, and the Early effect is negligible.

First, demonstrate that the transistor is in the active mode when the signal is zero. Then, calculate the gain v_o/v_i , the input resistance r_i , the overall gain v_o/v_s , and the maximum permissible peak-to-peak value of v_i for which v_o remains undistorted. Summarize your findings in Table 4.

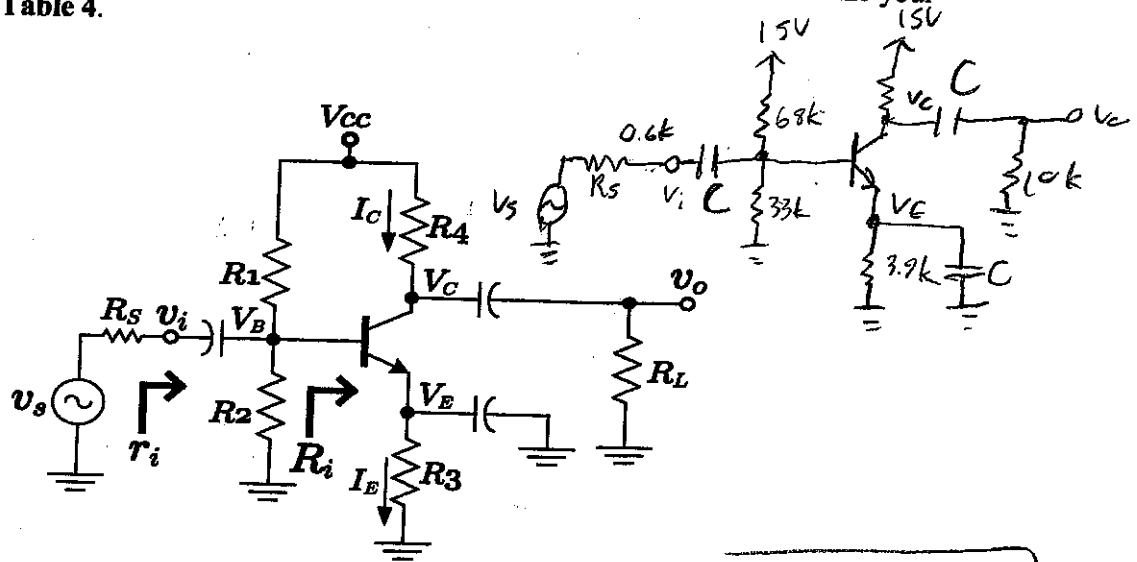
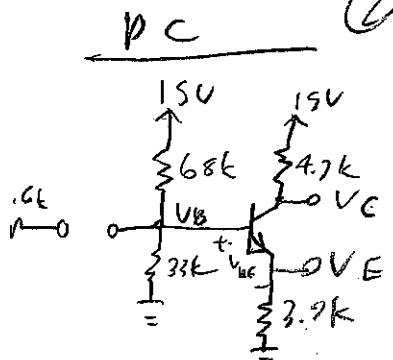


Fig. 4: Common-Emitter amplifier of Q4.

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Table 4: results for the amplifier of Fig. 4.

v_o/v_i [V/V]	r_i [k Ω]	v_o/v_s [V/V]	maximum permissible peak-to-peak swing of v_i
-13.41 $\frac{V}{V}$	4.67 k Ω	-13.06 $\frac{V}{V}$	



$$V_B = \frac{33 \cdot 15}{33 + 68} \approx 4.9\text{ V}$$

$$V_E = V_B - V_{BE} = 4.9\text{ V} - 0.7\text{ V} = 4.2\text{ V}$$

$$I_E = \frac{4.2\text{ V} - 0}{3.9} = 1.0769\text{ mA}$$

$$I_C = \frac{\beta}{\beta + 1} I_E = \frac{200}{200 + 1} (1.0769) = 1.0716\text{ mA}$$

$$I_C = \frac{15 - V_C}{4.7}$$

$$V_C = 15 - 4.7 I_C = 15 - 4.7(1.0716) = 9.96\text{ V}$$

$$V_{CE} = 9.96\text{ V} - 4.2\text{ V} = 5.76\text{ V} > 0.3\text{ V}$$

∴ Transistor is active