

※ 考生請注意：本試題不可使用計算機。請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

1. Consider a pn junction in thermal equilibrium at 300 K for which the doping concentrations of n and p are $N_D = 10^{20} \text{ cm}^{-3}$ and $N_A = 10^{18} \text{ cm}^{-3}$, respectively. The area for the pn junction is 10^{-4} cm^2 . What is the built-in voltage and depletion width of pn junction? What is the junction capacitance of pn junction at zero bias and reverse bias of -3.15 V? What is cutoff wavelength for this pn junction photodiode if semiconductor of this pn junction has band gap of 1.24 eV? (20%) ($\epsilon_0 = 8.854 \times 10^{-14} \text{ F/cm}$, relative dielectric constant of semiconductor = 11.7, and intrinsic carrier concentration of semiconductor = $2 \times 10^{10} \text{ cm}^{-3}$).

2. Sketch and label the voltage transfer characteristic v_o versus v_i of the circuit shown in Fig. 1 over a +- 10-V range of input signals. All diodes with $n = 1$ have 0.7-V drop at current of 1mA. What are the slopes of characteristics at the extreme +- 10-V levels? (20%)

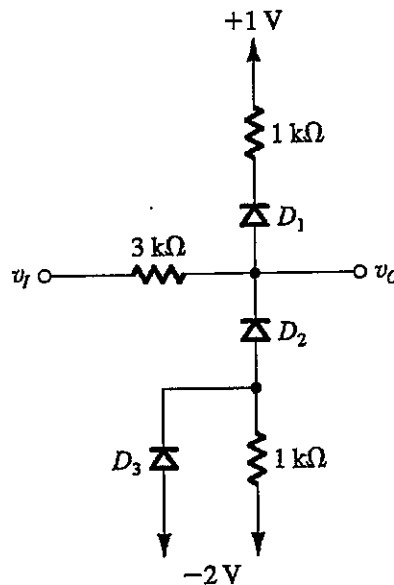


Fig. 1

3. For the circuit shown in Fig. 2, the transistor parameters are $\beta = 100$, $V_A = \infty$, $V_{BE(on)} = 0.7 \text{ V}$, and $kT/q = 25 \text{ mV}$. Performing the DC analysis, please find I_{B1} , I_{C1} , I_{E1} , I_{C2} , I_{E2} , V_{CE1} , and V_{CE2} . Plot the small signal equivalent circuit of the amplifier. Find out the parameters g_{m1} , g_{m2} , $r_{\pi1}$, and $r_{\pi2}$ of transistor Q_1 and Q_2 , respectively. Find the voltage gain v_o/v_s , the input resistance R_{is} , and the output resistance R_o of the amplifier. Determine the maximum undistorted swing in the output voltage. (20%)

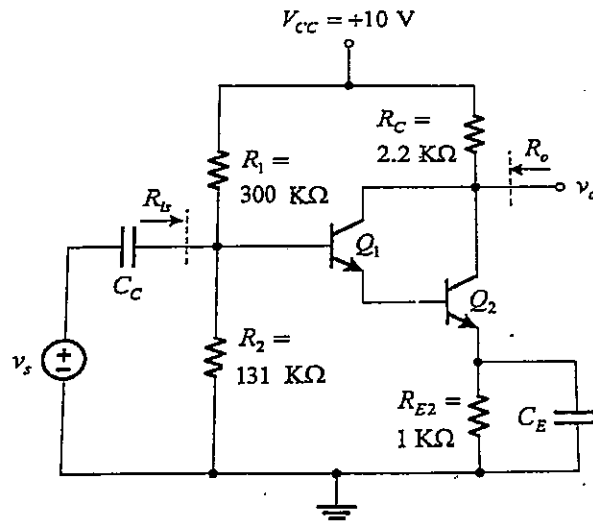


Fig. 2

4. Consider the differential amplifier showing in Fig. 3. Let $(W/L)_{M5} : (W/L)_{M6} = 1 : 4$. Assume all the devices are operated in saturation region, and R_L is much greater than r_o . (1) If M_1 and M_2 , M_3 , and M_4 are perfectly matched, $r_{o1} = r_{o2} = r_{o3} = r_{o6} = 100\text{k}\Omega$, $g_{m1} = g_{m2} = g_{m3} = g_{m4} = 1 \text{ mA/V}$. Please find the small signal differential mode voltage gain A_{dm} , the common mode voltage gain A_{cm} and common mode rejection ratio (CMRR). (2) If $(W/L)_{M1} : (W/L)_{M2} = 100 : 99$, $(W/L)_{M3} : (W/L)_{M4} = 99 : 100$, $\mu_n C_{ox}(W/L)_{M1} = 0.1 \text{ mA/V}^2$, and $\mu_n C_{ox}(W/L)_{M2} = 0.099 \text{ mA/V}^2$. Neglecting channel length modulation effect (r_o), find the input offset voltage. (20%)

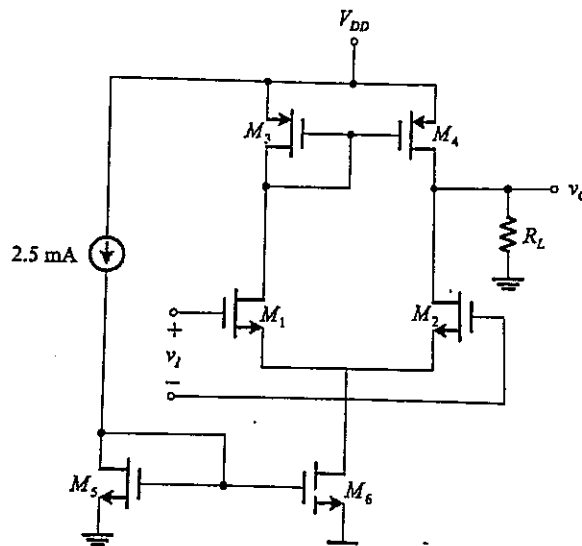


Fig. 3

5. for a circuit in the figure 4 please find the expression of input impedance Z_{in} . (20%) (Both OP-AMP A_1 and A_2 are ideal Op-AMP.)

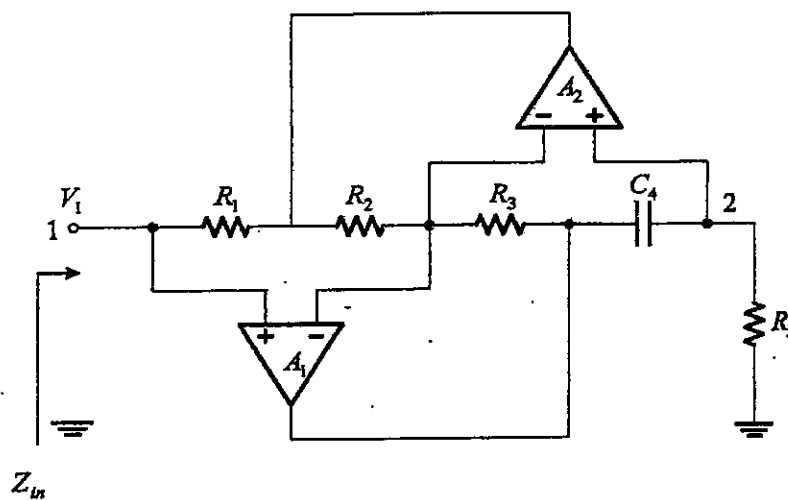


Fig. 4