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1. Consider the circuit shown in Figure 1 with parameters of R_s=10 kΩ, R_i=10 kΩ, C_i=10 pF, R_1=10 kΩ, R_2=20 kΩ, C_1=100 nF and G_m=100 mA/V.
   (a) Find $T_i(s) = V_i(s)/V_s(s)$ in the standard form of two polynomial expressions and the corresponding 3dB frequency. (6%)
   (b) Find $T(s) = V_o(s)/V_s(s)$ in the standard form of two polynomial expressions and the gain-bandwidth product. (10%)

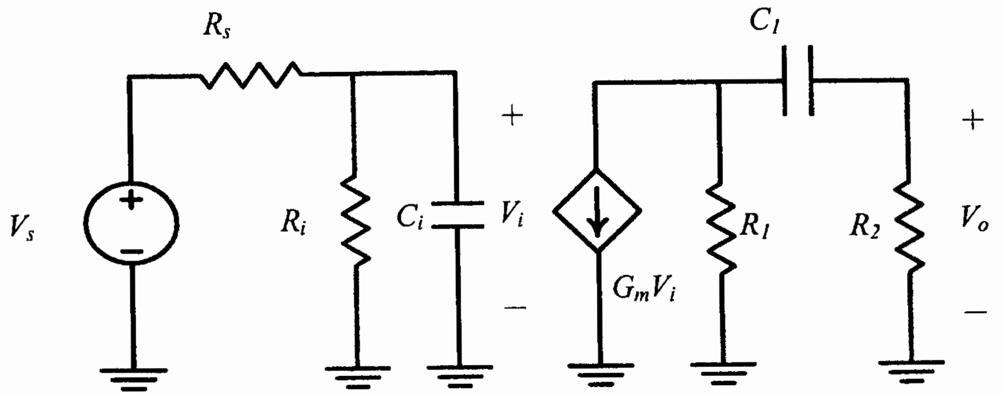

Figure 1

2. Consider the circuit shown in Figure 2 with parameters of V_{DD}=5 V, $\mu_n C_{ox}$= 40 μA/V^2, and $\mu_p C_{ox}$=20 μA/V^2, $|V_{tn0}|=|V_{tp0}|$=1V, γ=0.5V$^{1/2}$, 2Φ_f=0.6V, $(W/L)_{Q1}$=2 μm/1 μm, $(W/L)_{Qp}$=2 × $(W/L)_{Qn}$ =5 μm/1 μm, C = 10fF.
   (a) Determine threshold voltage of Q_1 after $v_I=V_{DD}$, $v_C=V_{DD}$ and v_x is stable. (4%)
   (b) Find noise margin V_{OH} of Q_1 when $v_I=V_{DD}$ and $v_C=V_{DD}$. (4%)
   (c) Determine the static current of the inverter, its power consumption and v_O when $v_I=V_{DD}$ and $v_C=V_{DD}$. (10%)

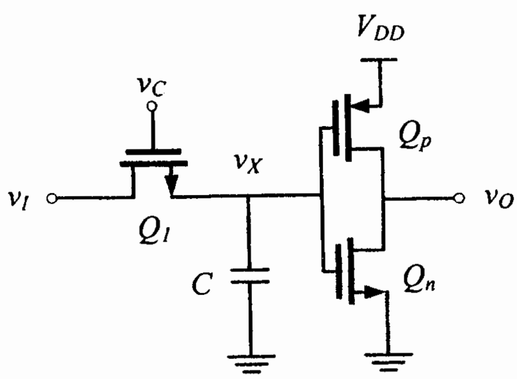

Figure 2

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3. It is required to design the circuit of Figure 3 to provide a constant current I_O=10μA.
   (a) Determine the values of the required resistors R_2 and R_3, assuming that I_{REF}=100μA, v_{BE}=0.7V at a 1-mA current, and β to be high. (6%)
   (b) If β = 200 and V_A=100V, find the value of the output resistance, and find the change in output current corresponding to a 5-V change in output voltage. (6%)

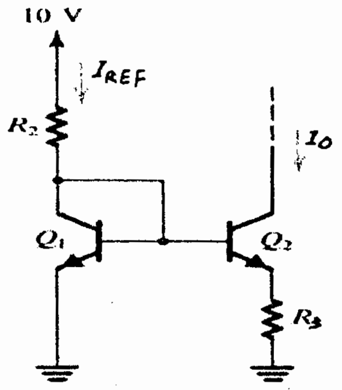

Figure 3

4. It is required to design the circuit of Figure 4 to provide a bias current I_B=225μA with Q_8 and Q_9 as matched devices having W/L = 60/0.5. Transistors Q_{10}, Q_{11}, and Q_{13} are to be identical, with the same g_m as Q_8 and Q_9. Transistor Q_{12} is to be four times as wide as Q_{13}. Let $\mu_n C_{ox} = 3\mu_p C_{ox}$ = 180 μA/V^2 and V_{DD}=V_{SS}= 1.5V.
   (a) Find the required value of R_B and the voltage drop across R_B. (4%)
   (b) Specify the W/L ratios of Q_{10}, Q_{11}, Q_{12}, and Q_{13}. (3%)
   (c) Give the expected dc voltages at the gates of Q_{12}, Q_{10}, and Q_8. (6%)

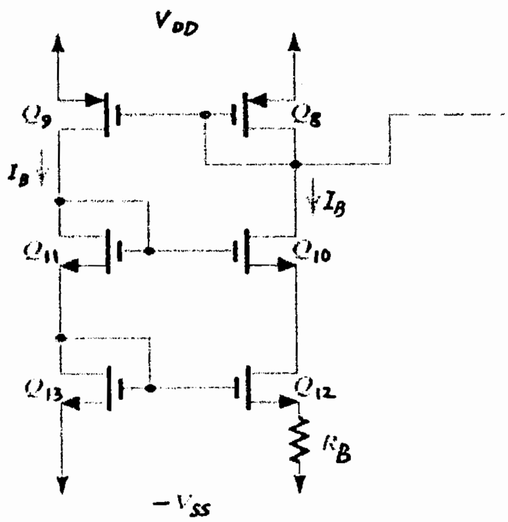

Figure 4

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5. Consider a feedback amplifier for which the open-loop gain A(s) is given by

$$A(s)=\frac{1000}{(1+s/10^4)(1+s/10^5)^2}$$

If the feedback factor β is independent of frequency, find the frequency at which the phase shift is 180°, and find the critical value of β at which oscillation will occur. (8%)

6. An amplifier has a dc gain of 10^5 and poles at 5 x 10^5 Hz, 10^7 Hz, and 5 x 10^8 Hz. To stabilize the amplifier with unity feedback ($\beta = 1$), move the first pole by introducing a compensation capacitor. Assume the second pole remains. Calculate the frequency of the first new pole to achieve a phase margin of 45°. (5%)

7. A prototype active filter with admittances Y_1 through Y_4 is shown in Figure 7a. Assume the Opamp is ideal. The transfer function of this filter is as follows

$$\frac{v_o\,(s)}{v_i\,(s)}=\frac{Y_1Y_2}{Y_1Y_2+Y_4(Y_1+Y_2+Y_3)}$$

A designed filter is the cascade of the prototype circuits shown in Figure 7b, where R = 10 kΩ, C = 0.01 μF, C_1 = 1.082C, C_2 = 0.9241C, C_3 = 2.613C, C_4 = 0.3825C

(a) Calculate the zeros and poles of the transfer function for this designed filter. (8%)

(b) What is the type of this filter (lowpass, highpass, bandpass, bandreject, or ....)? Explain why? (5%)

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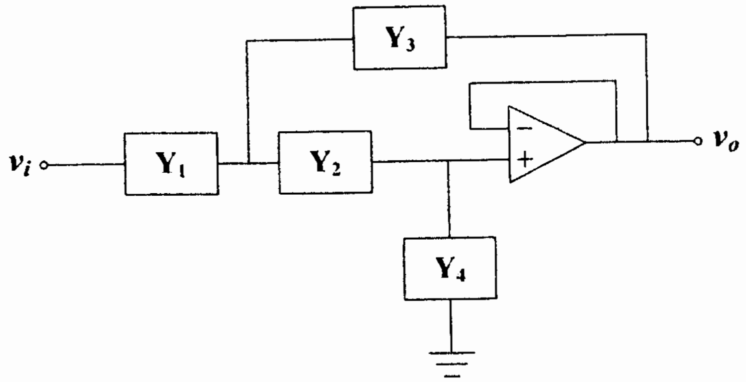

Figure 7a

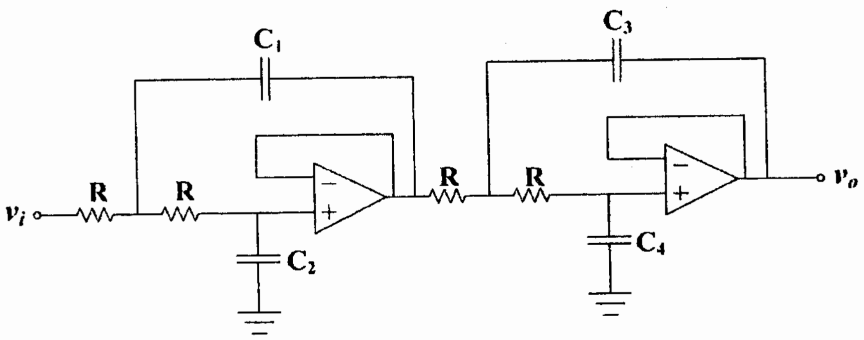

Figure 7b

8. A phase-shift oscillator is shown in Figure 8, where R = 10 kΩ, C = 10 nF
   (a) Find the loop gain by breaking the circuit at node X. (10%)
   (b) Calculate the oscillation frequency f_o, and the minimum required value of R_f for oscillation to start in this circuit. (5%)

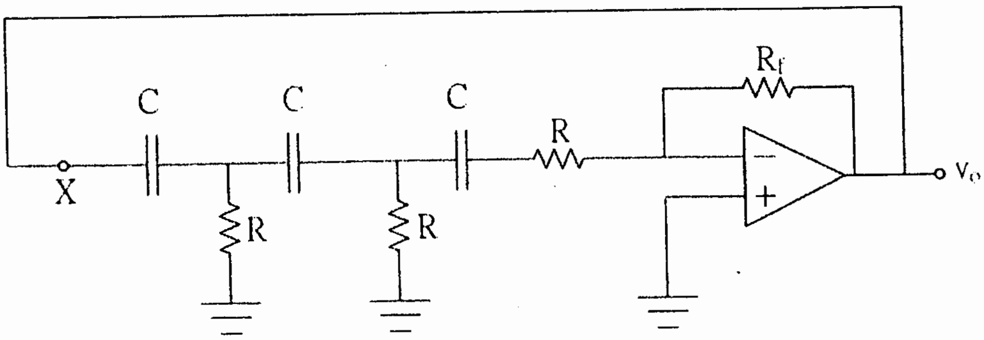

Figure 8