

EE112 Analog Integrated Circuits I

Homework 9

Due: Dec. 22th before lecture

Read the chapter 9.

1. For an NMOS differential pair with a common-mode voltage V_{CM} applied, as shown in Fig. 1, let $V_{DD} = V_{SS} = 1.0$ V, $k_n' = 0.4$ mA/V², $(W/L)_{1,2} = 10$, $V_m = 0.4$ V, $I = 0.16$ mA, $R_D = 5$ k Ω , and neglect channel-length modulation.
 - (a) Find V_{OV} and V_{GS} for each transistor.
 - (b) For $V_{CM} = 0$, find V_S , I_{D1} , I_{D2} , V_{D1} , and V_{D2} .
 - (c) Repeat (b) for $V_{CM} = +0.4$ V.
 - (d) Repeat (b) for $V_{CM} = -0.1$ V.
 - (e) What is the highest value of V_{CM} for which Q_1 and Q_2 remain in saturation?
 - (f) If current source I requires a minimum voltage of 0.2 V to operate properly, what is the lowest value allowed for V_S and hence for V_{CM} ?

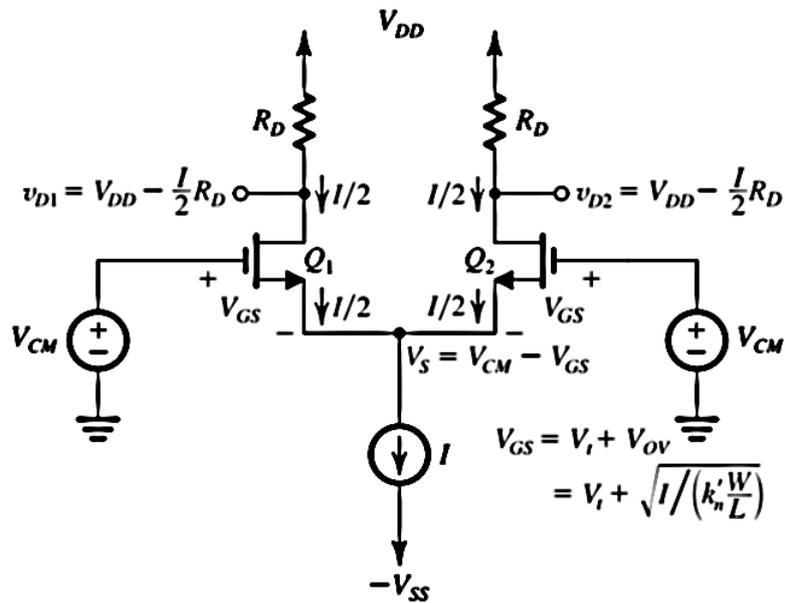


Figure 1

2. For the differential amplifier shown in Fig. 2, let Q_1 and Q_2 have $k_p'(W/L) = 4$ mA/V², and assume that the bias current source has an output resistance of 30 k Ω . Find $|V_{OV}|$, g_m , $|A_d|$, $|A_{cm}|$, and the CMRR (in dB) obtained with the output taken differentially. The drain resistances are known to have a mismatch of 2%.

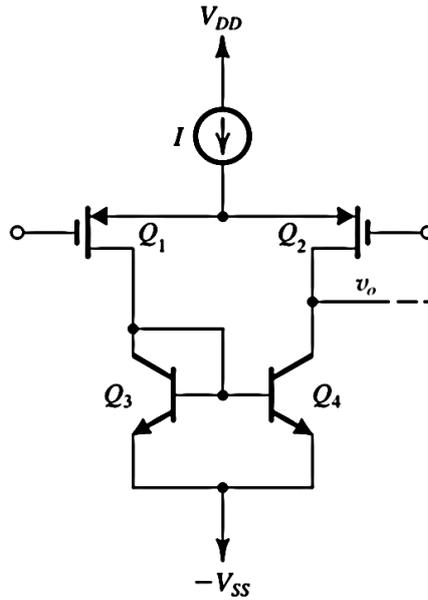


Figure 4

5. Consider the circuit in Fig. 5 with the device geometries (in μm) shown in Table I. Let $I_{\text{REF}} = 225 \mu\text{A}$, $|V_{t}| = 0.75 \text{ V}$ for all devices, $\mu_n C_{ox} = 180 \mu\text{A}/\text{V}^2$, $\mu_p C_{ox} = 60 \mu\text{A}/\text{V}^2$, $|V_A| = 9 \text{ V}$ for all devices, $V_{DD} = V_{SS} = 1.5 \text{ V}$. Determine the width of Q_6 , W , that will ensure that the op amp will not have a systematic offset voltage. Then, for all devices evaluate I_D , $|V_{OV}|$, $|V_{GS}|$, g_m , and r_o . Provide your results in a table similar to Table I. Also find A_1 , A_2 , the open-loop voltage gain, the input common-mode range, and the output voltage range. Neglect the effect of V_A on the bias currents.

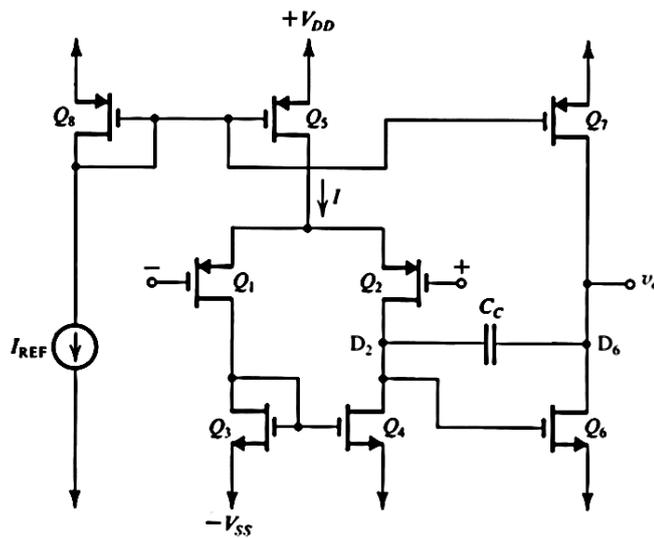


Figure 5

Transistor	Q_1	Q_2	Q_3	Q_4	Q_5	Q_6	Q_7	Q_8
W/L	30/0.5	30/0.5	10/0.5	10/0.5	60/0.5	$W/0.5$	60/0.5	60/0.5

Table I