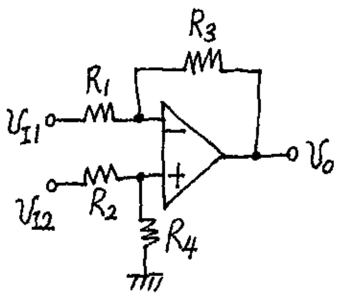
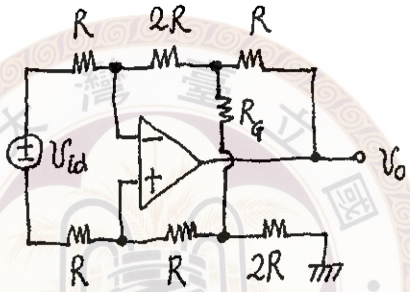
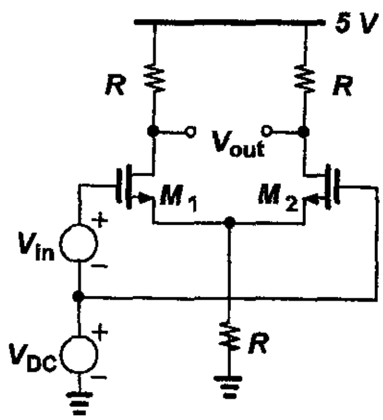
1. The circuit shown on the right-hand side is a single OPAMP difference amplifier. Assume the OPAMP is ideal.
   (a) Find the common mode gain and the common mode input resistance of the difference amplifier. (9%)
   (b) Find the differential gain and CMRR (common mode rejection ratio) of the difference amplifier. (9%)



2. Assume the OPAMP in the following circuit is ideal. Find the voltage gain of the amplifier, v_o/v_{id}. (15%)



3. The following circuit is a differential amplifier, where the current source is replaced by a fixed resistor R. Neglect channel-length modulation and body effect in all transistors. Note that $(W/L)_{1,2}=80/1$, R=1 KΩ, $\mu_n C_{ox}=50\ \mu A/V^2$ and $V_{tn}=1V$. Additionally, V_{DC} is equal to 2.5V and V_{in} is a differential AC signal.
(a) (5%) What is the differential gain of this amplifier ($=A_v= V_{out}/V_{in}$)?
(b) (12%) Derive (dA_v/dV_{DC}) (Take derivative of A_v with respect to V_{DC}), where V_{DC} is around 2.5V.
(c) (4%) If the 1-KΩ resistor is replaced by an ideal current source, what's the major advantage of the modified circuit can obtain?



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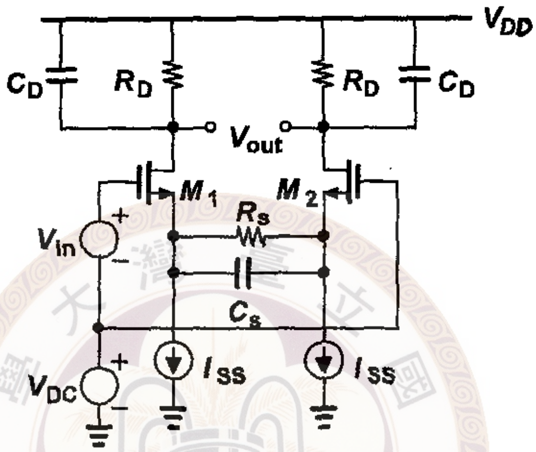
4. Now, the frequency response of the differential pair with source degeneration can be analyzed. Neglect channel-length modulation, body effect and parasitic capacitance in all transistors. Assume both M_1 and M_2 are in saturation region and their transconductance is equal to g_m. Note that $g_m R_s = 1$ and $R_D C_D = R_s C_s$.

(a) (9 %) Derive $V_{out}(s)/V_{in}(s)$ and calculate -3dB frequency.

(b) (4%) What is the 3-dB BW improvement compared with the same circuit whose C_s is removed?



5. Consider the circuit shown below. The opamp is assumed ideal (i.e., infinite gain, infinite bandwidth, infinite driving force, infinite input impedance, and zero output impedance) and with symmetric dual supplies [the saturated (maximum) output of the opamp is $+V_{CC}$ or $-V_{CC}$]. At $t = 0^-$, $V_C = +V_{CC}$ and $i_C = 0$.

(i) Sketch V_{out}, V^+, and V^- as a function of time and mark important points, starting from $t = 0^-$. (V^+ and V^- represent the plus and minus input nodes of the opamp, respectively.) Does the circuit in (a) oscillate? If so, what is the period of oscillation? (8%)

(ii) Now the input polarity of the opamp is flipped as illustrated in (b). Repeat part (i). (8%)

(iii) Is the circuit in (b) a positive or negative feedback? Explain your answer. (9%)

(iv) Now an ideal diode is inserted in series with R_1 as shown in (c). Repeat part (i). (8%)