Electronics II, Exam-4, Spring 2022

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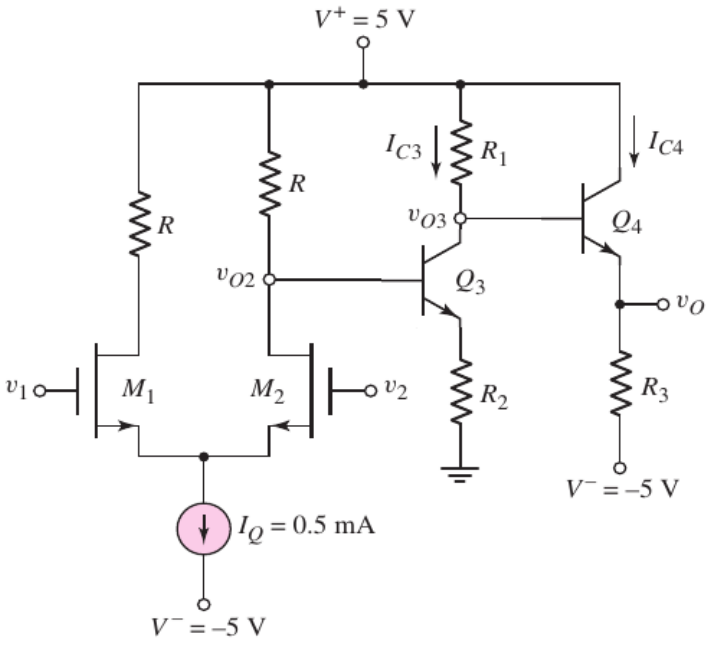
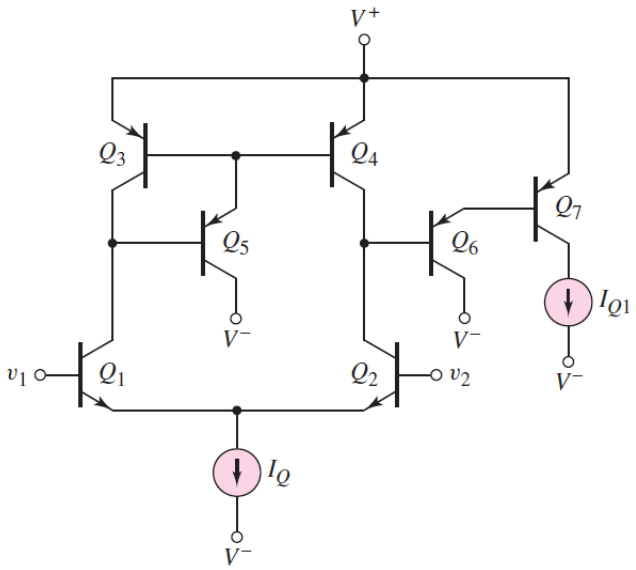
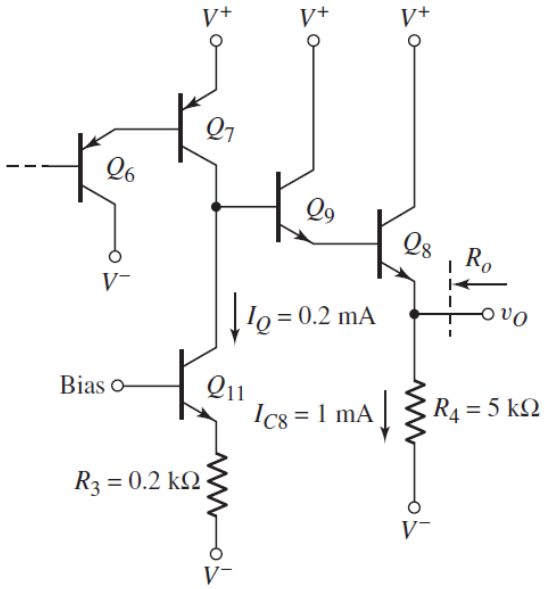
1. (30%) Suppose that the output resistance of the current source is R_o, the transconductance of the MOS transistors is g_m, and the common-emitter current gain of the BJT transistors is β.
   (a) Sketch the small-signal equivalent circuit and derive the expression of the voltage gain v_O / v_{O2}. (10%)
   (b) Sketch the small-signal equivalent circuit and derive the expression of the common-mode voltage gain $A_{cm1} = v_{O2} / v_1$. (10%)
   (c) Derive the overall CMRR_{dB}. (5%)
   (d) Sketch the small-signal equivalent circuit and derive the output resistance looking from v_O. (5%)



2. (15%) The diff-amp has a three-transistor active load circuit and a Darlington pair configuration connected to the output. Determine the bias current I_{Q1} in terms of I_Q such that the diff-amp dc currents are balanced.



3. (20%) The output stage is a Darlington pair emitter-follower configuration. Assume $\beta = 120$ for all npn transistors and $\beta = 90$ for all pnp transistors. Let $V_{A7} = 60$ V for Q_7, $V_{A11} = 120$ V for Q_{11}, and $V_A = \infty$ for all other transistors. Determine the output resistance *Ro*.



4. (35%) Consider the following BJT operational amplifier circuit, in which the transistor parameters are: $\beta = 120$, $V_{BE}(\text{on}) = 0.7V$ (except for Q_8 and Q_9), and $V_A = \infty$. We have $I_Q = 0.4mA$.
   (a) Find the dc output voltage V_O. (10%)
   (b) Find the input resistances R_{i2} and R_{i3}. (10%)
   (c) Determine the overall differential-mode voltage gain $A_d = v_o/(v_1 - v_2)$. (15%)