MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Electrical Engineering and Computer Stuff

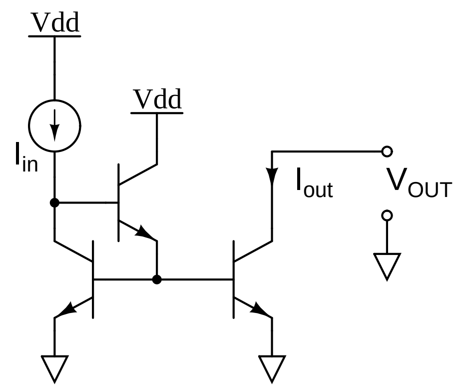
6.301 Solid State Circuits

Spring Term 2003 — Issued : March 14, 2003
Problem Set 5 — Due : Friday, March 21, 2003

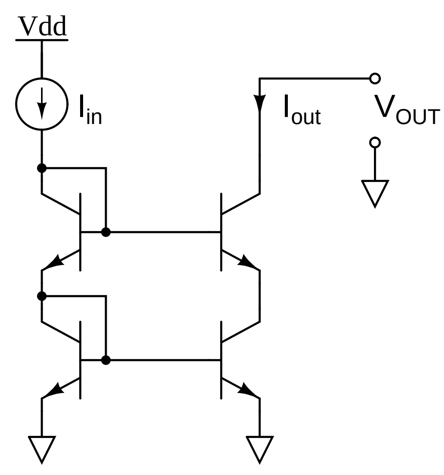
Problem 1: Current Mirrors.

(a) For each of the following current mirrors, express I_{out}/I_{in} as a fraction of expanded polynomials in β. Also, solve for the lower bound of V_{OUT} such that all transistors remain Forward Active in terms of V_{BE} and $V_{CE,sat}$. You cannot neglect base currents.

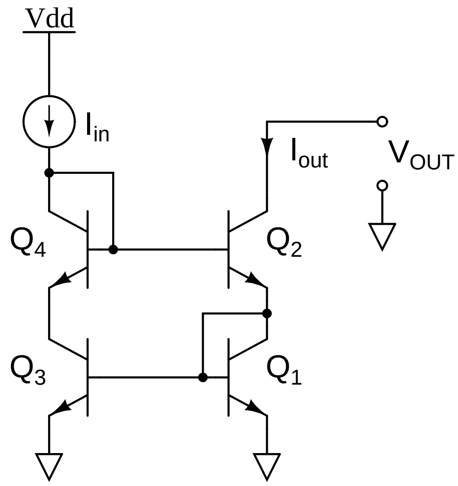
(i) Improved Current Mirror:



(ii) Cascode Current Mirror:

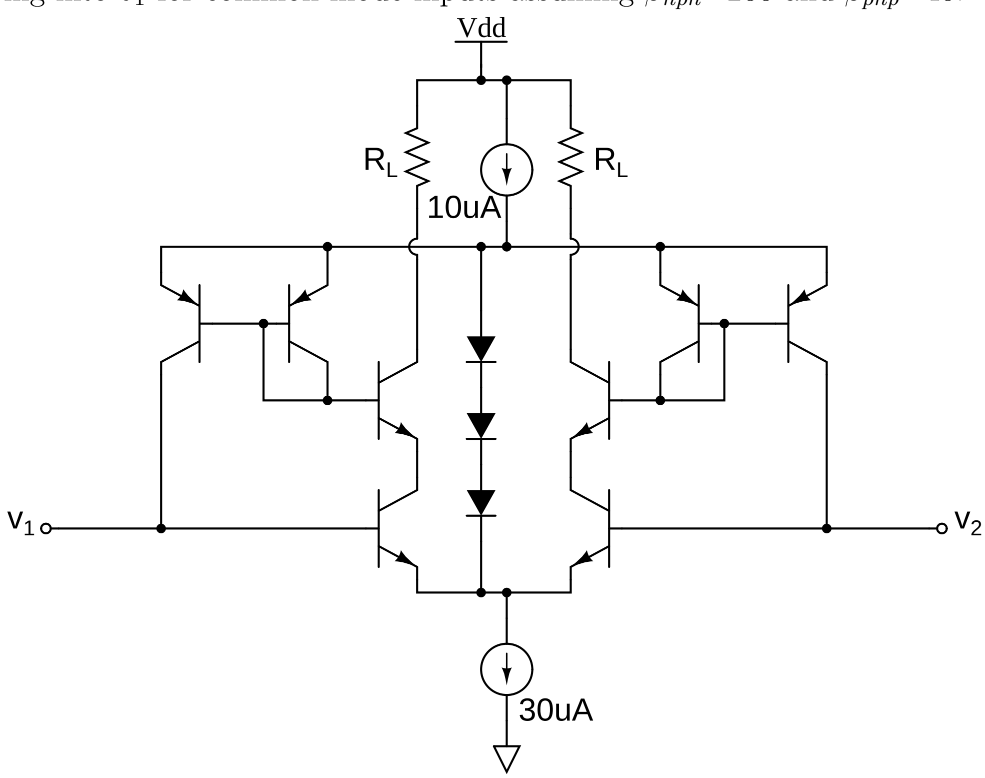


(iii) Improved Wilson Current Mirror:

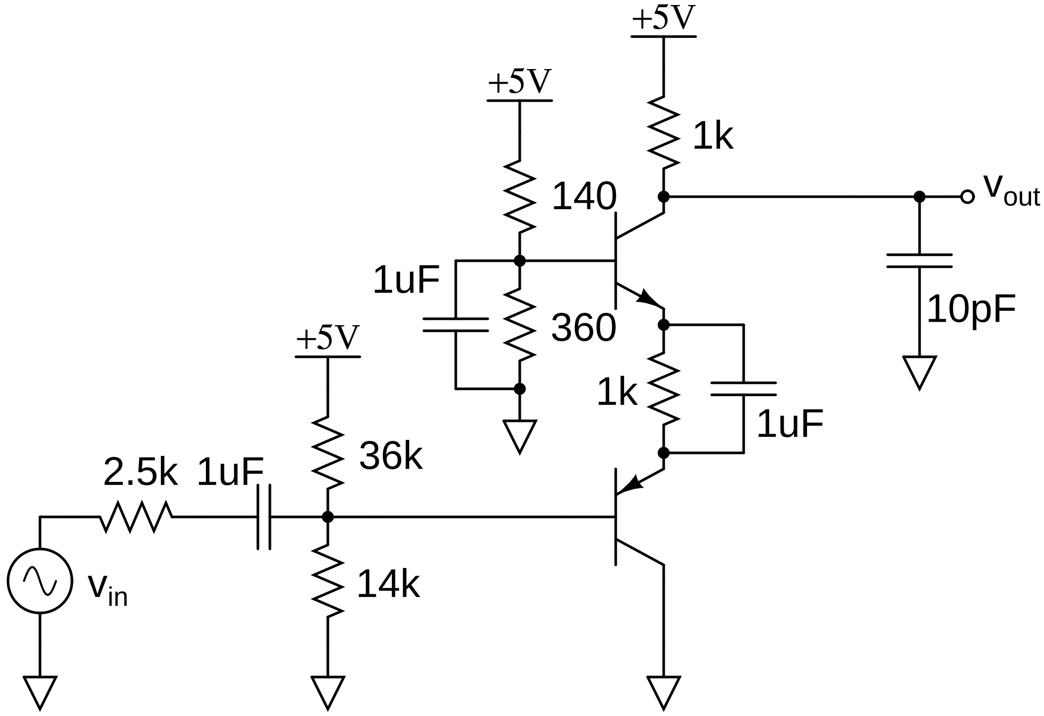


(b) Calculate R_o for the Improved Wilson Current Mirror. First, write it in terms of small-signal parameters r_o, g_m and r_π; then make some approximations to simplify your expression.

Problem 2: The following is a simplified version of the input stage for the OP07 Ultralow Offset Voltage Operation Amplifier from Analog Devices. Calculate the input current flowing into v_1 for common-mode inputs assuming β_{npn}=200 and β_{pnp}=40.



Problem 3: The following amplifier is in a stacked Emitter-Follower, Common-Base configuration. Assume $V_{BE,on}$=0.6V, c_μ=2pF, c_π=20pF, β_{npn}=200 and β_{pnp}=100. You may neglect r_b and r_o.

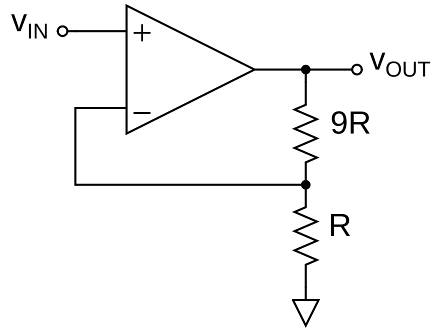


(a) Calculate the midband small-signal gain.

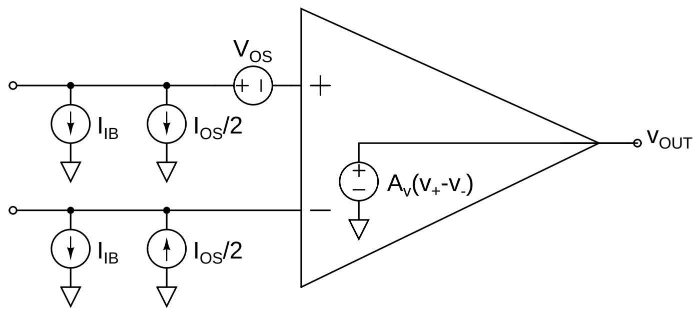
(b) Using the OCT method, estimate the upper −3dB frequency.

(c) Using the SCT method, estimate the lower −3dB frequency.

Problem 4: Operational Amplifiers. Consider the following non-inverting configuration:



We know that practical op amp circuits do not implement "ideal op amp" behavior. This is the op amp equivalent circuit including Input Offset Voltage V_{OS}, Input Bias Current I_{IB}, Input Offset Current I_{OS}, and Finite Gain A_V:



(a) For the non-inverting op amp configuration, solve v_{OUT} in terms of v_{IN} and the following non-idealities.

(i) Input Offset Voltage V_{OS} (assuming no I_{IB} or I_{OS}; and infinite gain)

(ii) Input Bias Current I_{IB} (assuming no V_{OS} or I_{OS}; and infinite gain)

(iii) Input Offset Current I_{OS} (assuming no V_{OS} or I_{IB}; and infinite gain)

(iv) Finite Gain A_V (assuming no V_{OS}, I_{IB} or I_{OS})

(b) It is possible to counteract the dependence on I_{IB} found in part (a-ii) with a resistor in series with the non-inverting terminal. Find the value of R' which eliminates the dependence on I_{IB} found in part (a-ii).