MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Electrical Engineering and Computer Stuff

6.301 Solid State Circuits

Fall Term 2010 | Issued : Oct. 8, 2010
Problem Set 5 | Due : Friday, Oct. 15, 2010

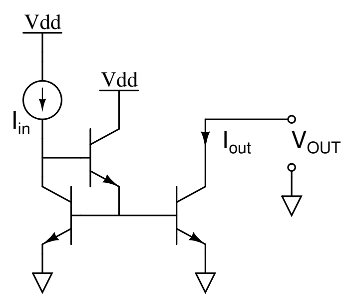
Suggested Reading: Read as many of the following as you can. All of the recommended references are on reserve at Barker Library.

1. Lundberg sections 11–18, 21 and 27.
2. Grebene sections 4 and 7.
3. Gray and Meyer sections 4.2, 6.2 and 7.3.6.

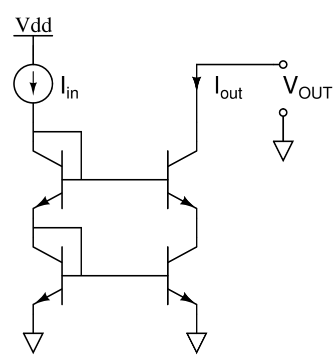
Problem 1: Current Mirrors.

For each of the following current mirrors, express I_{out}/I_{in} as a fraction of expanded polynomials in β, assuming all transistors are matched. 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.

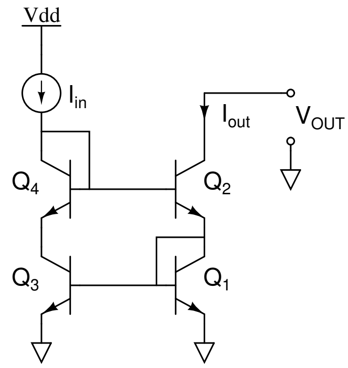
(i) Improved Current Mirror:



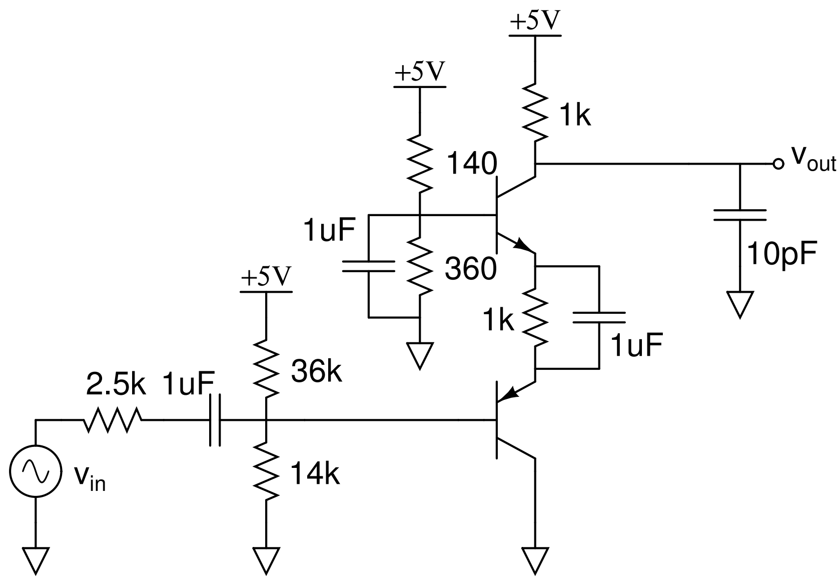
(ii) Cascode Current Mirror:



(iii) Improved Wilson Current Mirror:



Problem 2: 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.

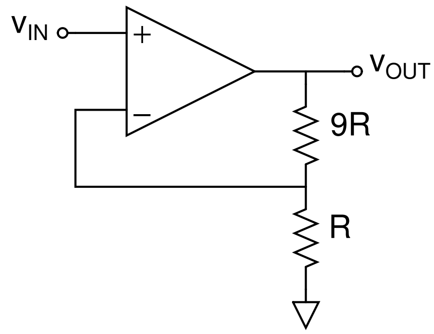


(a) Calculate the midband small-signal gain.

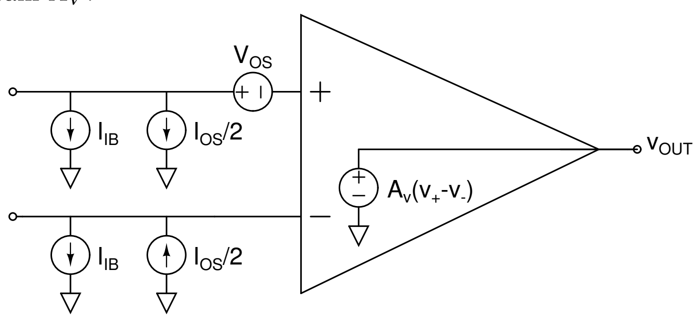
(b) Using the OCT method, estimate the upper −3dB frequency.

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

Problem 3: 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).