MASSACHUSETTS INSTITUTE OF TECHNOLOGY

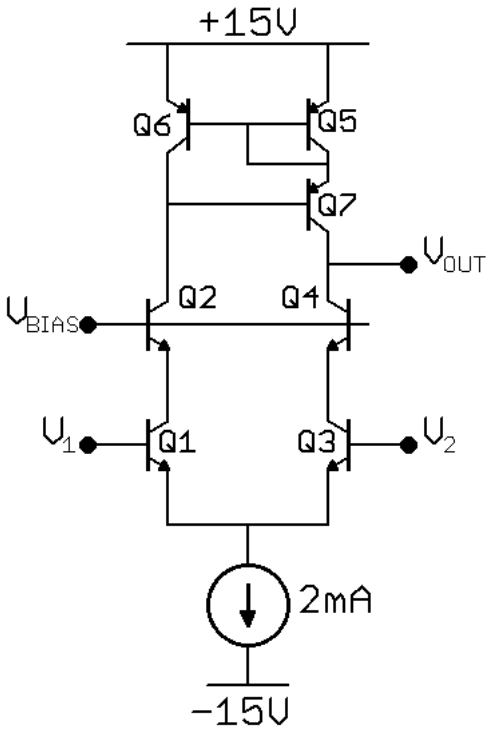
Department of Electrical Engineering and Computer Science

6.301 Solid State Circuits

Fall 2013 — Issued : Oct 22, 2013

Problem Set 6 — Due : Oct 29, 2013

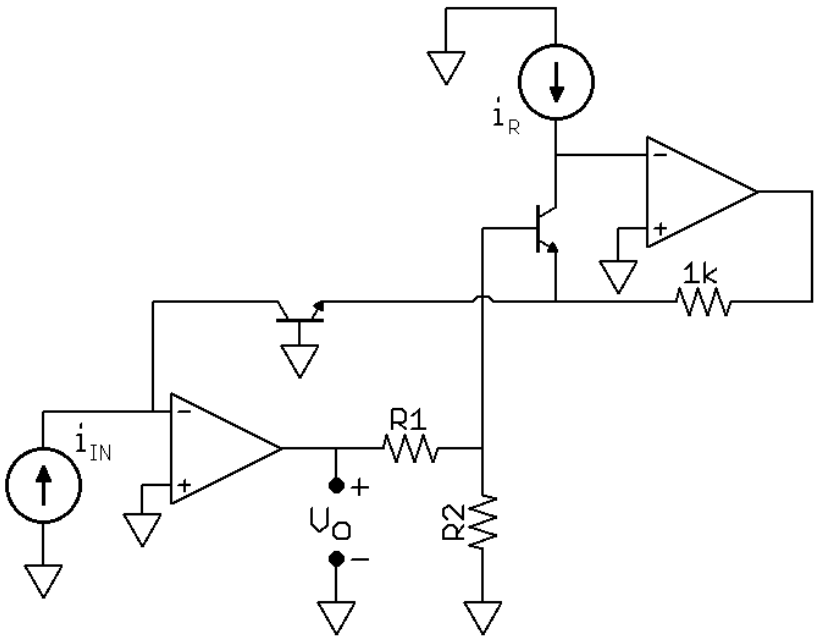
Problem 1: Differential Pair with Active Load



Find $\frac{v_{out}}{v_1 - v_2}$ at midband, assuming $\beta_{npn} = 200$, $\beta_{pnp} = 50$, $V_{A,npn} = 100\text{V}$, $V_{A,pnp} = 50\text{V}$, Common-Mode Voltage $V_{CM} = 0$, and $V_{BIAS} = 4\text{V}$.

Problem 2: Op Amp Applications

Assume the following circuit is operating at room temperature ($T = 300K$)

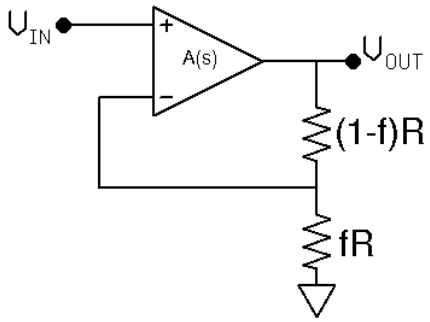


(a) When $R_1 = 15.7R_2$, v_o is of the form $v_o = Alog_{10}(x)$. Find A and x.

(b) Solve for R_1 in terms of R_2 such that $v_o = Alog_2(x)$ behavior.

Problem 3: Op Amp Frequency Response

The following op amp has a finite gain with frequency response $A(s) = \frac{a_o}{\tau s+1}$
$a_o = 10^6$, $\tau = 10^{-6}$, and $f = [1, 0.1, 0.01, 0.001]$.

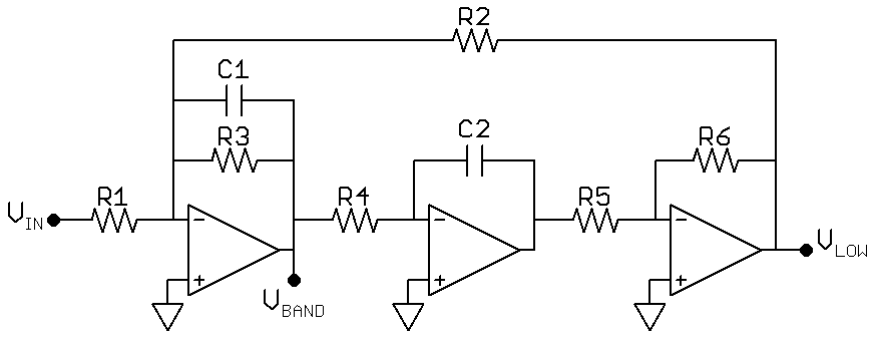


(a) Solve for the closed-loop DC gain and upper -3dB frequency for each value of f.

(b) Sketch the Bode Plot magnitude of $\frac{V_{OUT}}{V_{IN}}(s)$ for each value of f on one plot.

(c) What effect does f (gain) have on the step response?

Problem 4: Op Amp Filter



Find the transfer functions $\frac{V_{LOW}}{V_{IN}}(s)$ and $\frac{V_{BAND}}{V_{IN}}(s)$ such that the denominator is of the form:

$$D(s) = s^2 + \zeta\omega_o s + \omega_o^2 \tag{1}$$

Find ζ and ω_o.