EE 321 Analog Electronics, Fall 2012
Exam 1 October 1, 2012
Solution

This is a closed-book exam. Calculators allowed. The exam is designed for conceptual understanding not long derivations. You MUST box your answer. Correct answer boxed and derivation gives you 10 points. Either is 5 points. Neither is 0 points.

You have a source, v_S with output resistance $R_S = 1\,\mathrm{k\Omega}$, amplifier A with gain $A_{voA} = 10$, $R_{\mathrm{inA}} = 1\,\mathrm{k\Omega}$, and $R_{\mathrm{outA}} = 10\,\mathrm{k\Omega}$, amplifier B with gain $A_{voB} = 10$, $R_{\mathrm{inB}} = 10\,\mathrm{k\Omega}$, and $R_{\mathrm{outB}} = 1\,\mathrm{k\Omega}$, and a load $R_L = 1\,\mathrm{k\Omega}$. Which arrangement, source-A-B-load, or source-B-A-load will result in the largest overall G_v, and what is that value?

1. **Compute G_v for the source-A-B-load sequence.**

$$\begin{aligned}G_v =&\frac{R_{\mathrm{inA}}}{R_{\mathrm{inA}}+R_S} \times A_{voA} \times \frac{R_{\mathrm{inB}}}{R_{\mathrm{outA}}+R_{\mathrm{inB}}} \times A_{voB} \times \frac{R_L}{R_L+R_{\mathrm{outB}}}\\ =&\frac{1}{1+1} \times 10 \times \frac{10}{10+10} \times 10 \times \frac{1}{1+1}\\ =&12.5\end{aligned}$$

2. **Compute G_v for the source-B-A-load sequence and indicate which of the two sequences produces the greater G_v.**

$$\begin{aligned}G_v =&\frac{10}{10+1} \times 10 \times \frac{1}{1+1} \times 10 \times \frac{1}{1+10}\\ =&4.13\end{aligned}$$

   Thus, SABL configuration creates the larger gain.

We model an op-amp open-loop gain in the usual way as a LP circuit with $A_0 = 10^6$ and $f_0 = 10\,\mathrm{Hz}$.

3. **What is the bandwidth of an amplifier, built with this op-amp, which has a gain of 10^3?**

   $\mathrm{GBWP} = 10 \times 10^6 = 10^7$. $\mathrm{BW} = \frac{\mathrm{GBWP}}{G} = \frac{10^7}{10^3} = 10^4\,\mathrm{Hz}$.

4. **If you cascade two amplifiers to get a total gain of 10^3, what is the bandwidth?**

   $\mathrm{BW} = \frac{\mathrm{GBWP}}{\sqrt{G}} = \frac{10^7}{\sqrt{10^3}} = 3.2 \times 10^5\,\mathrm{Hz}$.

An op-amp has $V_{OS} = 1\,\mathrm{mV}$ and $I_B = 1\,\mu\mathrm{A}$. You use it to build a inverting amplifier with input resistance $1\,\mathrm{k}\Omega$.

5. **If the gain is -100 how big (absolute value) can the output get for zero input?**

   The effect of V_{OS} is

$$V_o = (|G| + 1)\, V_{OS} = 101 \times 10^{-3} = 101\,\mathrm{mV}$$

   The effect of I_B is

$$V_o = -I_B R_2 = I_B G R_1 = -100 \times 10^{-6} \times 10^3 = -100\,\mathrm{mV}$$

   Total effect is (absoluate) $V_O = 201\,\mathrm{mV}$.

6. **What value of the gain will produce a maximum (again absolute) output of $1\,\mathrm{V}$?**

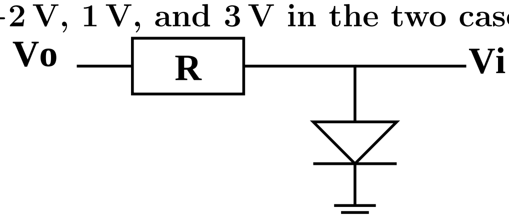
   Write (in absolute terms)

$$V_o = I_B |G| R_1 + (|G| + 1) V_{OS}$$

$$|G| = \frac{V_O - V_{OS}}{I_B R_1 + V_{OS}} = \frac{1 - 10^{-3}}{10^{-6} \times 10^3 + 10^{-3}} = 500$$

   so $G = -500$ is the largest we can allow.

Consider this diode circuit with $R = 10\,\Omega$. Compute the value of V_o for three different values of V_i, $-2\,\mathrm{V}$, $1\,\mathrm{V}$, and $3\,\mathrm{V}$ in the two cases below.



7. **When modeling the diode as a fixed voltage drop, $V_D = 0.7\,\mathrm{V}$.**

   In this case output equals V_D when $V_i \geq V_D$. So the answers are $-2\,\mathrm{V}$, $0.7\,\mathrm{V}$, and $0.7\,\mathrm{V}$.

8. **When modeling the diode as a piecewise linear model with $V_{D0} = 0.65\,\mathrm{V}$, and $r_D = 5\,\Omega$.**

   in this case the output equals

$$V_O = \begin{cases} 0 & V_i < V_{D0} \\ V_{D0} + \frac{V_i - V_{D0}}{3} & V_i > V_{D0} \end{cases}$$

   So we get for the three cases $-2\,\mathrm{V}$, $0.77\,\mathrm{V}$, and $1.43\,\mathrm{V}$.