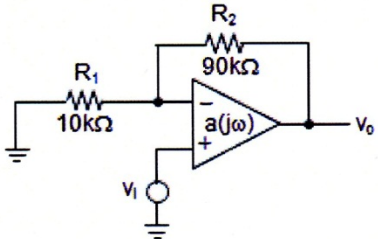
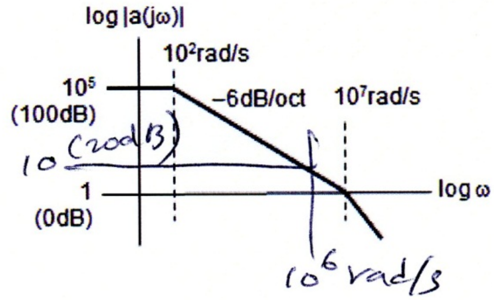
MS Exam: ECE 102 (Spring 2012)

Problem #1





An operational amplifier is used to make a feedback amplifier as shown above. Its open-loop Bode gain plot is also sketched with straight lines. It has two poles at 10^2 and 10^7 rad/s, respectively.

1. Using the same straight line, sketch the frequency response v_o/v_i on the above plot, and mark the low-frequency gain and the cut-off frequency.

$$f = \frac{10k}{10k+90k} = \frac{1}{10}, \quad \text{Gain} = 10, \quad BW = \frac{10^7}{10} = 1$$

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2. Is the phase margin greater than 60°? Explain why.

$$PM = 90° - \tan^{-1}\frac{10^6}{10^7} = 90° - \tan^{-1}\frac{1}{10} > 60°$$

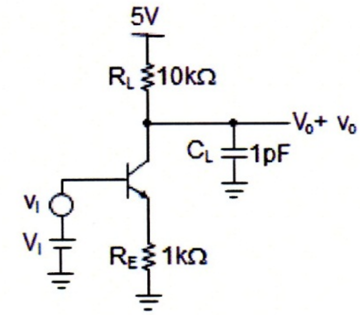
3. If $v_i(t) = \sin(10^6 t)$ in steady state, what is $v_o(t)$?

$$v_o(t) \hat{=} 0.71 \sin\left(10^6 t - \frac{\pi}{8}\right)$$

4. If the low-frequency output resistance of the opamp is 1kΩ, what is the low-frequency output resistance of this amplifier?

$$R_o \hat{=} \frac{1k\Omega}{10^4} = 0.1\Omega$$

Problem #2



An emitter degenerated bipolar amplifier is shown with the input bias voltage V_i. The input and output small signals are marked as the low-case v_i and v_o, respectively. Use the followings: $kT/q = 25mV$, $V_{BE} = 0.7V$, $V_{CEsat} = 0.2V$.

1. What is the maximum bias voltage V_i to keep the transistor in the forward-active range of operation?

$$5 - 10(V_i - 0.7) - 0.2 = V_i - 0.7$$

$$11 V_i = 12.5, \quad V_i \cong 1.1V$$

2. What is the DC bias voltage V_i to set the output DC voltage to be 3V?

$$\frac{V_i - 0.7}{1K} = 0.2mA, \quad V_i = 0.9V$$

3. Estimate the low-frequency small-signal voltage gain v_o/v_i in the above bias condition.

$$A_v \cong -\frac{R_L}{R_E} = -10$$

4. What is the -3dB bandwidth?

$$BW = \frac{1}{2\pi \times 10K \times 1pF} \cong 16MHz$$