6.331 Advanced Circuit Techniques

Spring Term 2002   Issued : February 5, 2002
Problem Set 1   Due : Friday, February 8, 2002

You should feel comfortable (although not necessarily ecstatic) with these problems if you intend to take 6.331.

Problem 1 A bipolar transistor with $f_T = 100$ GHz is operating a $I_C = 0.1$ μA. Using the charge control model, find the forward charge in the base, q_F. How many electrons is this?

Problem 2 Determine the transistors that actually contribute to signal amplification for each of the following amplifiers

   (a) μA733

   (b) μA741

   (c) LF357

   (d) OP-37

Problem 3 An operational amplifier is available with a fixed, unloaded open-loop transfer function

$$A(s) = \frac{10^5}{10^{-2}s + 1}$$

This amplifier is to be used as a unity-gain inverter. A load capacitor adds a pole at $s = -10^6$ radians per second to the unloaded open-loop transfer function. Compensate this configuration with an input lead network so that its loop-transmission magnitude is inversely proportional to frequency from low frequencies to a factor of five beyond the crossover frequency. Choose element values to maximize crossover frequency subject to this constraint. Assume high input impedance for the amplifier.

Problem 4 A two-stage operational amplifier is connected as an inverting differentiator with a feedback resistor of 100 kΩ and an input capacitor of 1 μF. What type of minor-loop compensating network should be used to stabilize this configuration? Determine element values that result in a predicted crossover frequency of 10^4 radians per second with a value of 0.2 m℧ for input-stage transconductance.

When this type of compensation is tried using an LM301A operational amplifier, minor loop stability is unacceptable, and it is necessary to shunt the compensation terminals with a 3-pF capacitor in addition to the network developed above for satisfactory performance. Describe the effect of this modification on closed-loop performance.