MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Electrical Engineering and Computer Science

6.301 Solid State Circuits

Fall Term 2010   Issued : Friday, Oct. 1, 2010
Lab 2   Due : Friday, Oct. 29, 2010

Work independently. Consultation with the 6.301 staff and other inanimate objects is encouraged. Computer and experimental verification of your final design is required. This is a non-trivial design assignment, so <u>start to work on it now</u>.

Read appendices B, C, D, and E in Dr. Lundberg's notes. Reread the Lab Reference. Pay close attention to everything written about laying out your circuit, avoiding oscillations, and writing your lab report. You will be held responsible for all the material in the Lab Reference at your checkoff.

Project :

You are to design, build, and test a broadband amplifier which meets the specifications listed below. The proper design procedure is first to complete a paper design based on *typical* performance data from the spec sheets and your experience. Then, and only then, confirm your design using HSPICE. When you are confident of your design, build and test it in the lab. Prepare a lab report detailing your design effort, results and conclusions, with particular emphasis on explaining discrepancies between your theoretical and experimental results.

midband voltage gain	$A \geq 1,000$ (60 dB)
upper half power frequency	$f_h \geq 4$ MHz
lower half power frequency	$f_l \leq 100$ kHz
source resistance	$R_S = 5$ kΩ
output capacitance loading	$C_L = 10$ pF
output voltage swing	$S_O > 2$ Vpp
power consumption	$P \leq 75$ mW
power supply voltages	0V, ± 5V, ± 15 V
transistors (no more than 6)	2N3904, 2N3906

In order to receive full credit, your paper design must meet specifications as verified by HSPICE, and your lab results must be consistent with theory.

Again, this is a difficult design assignment, so <u>start to work on it now</u> (like today). Absolutely no extensions will be given for this lab. The staff will have no sympathy for those who wait until the last minute.

6.301 Lab 2 Helpful Hints

1. Assume typical hybrid-pi parameters. If you have to go to lab and make a few measurements (on β_0 and c_μ for example), do it! The better your model is, the better your design will be. Don't forget to include the effect of r_b ($r_b = 200\ \Omega$). You can make arguments that the other spec sheet data is pessimistic, *if you have data to back it up.*

2. The output capacitance loading ($C_L = 10$ pF) is provided by the scope probe. However, some of the probes in lab are 10 pF probes, some are 13 pF, and some are 67 pF! Be sure that you are using the proper probe.

3. Neatness REALLY matters now! Try to keep lead lengths short to minimize parasitic inductances. Keep wires out of the signal path. Don't be afraid to clip component leads to make a neater, tighter layout. (See "Nerd Kit Layout" in the notes for more hints on layout and minimizing parasitic protoboard capacitances.)

4. As in Lab 1, you should properly terminate and attenuate the output of the signal generator with a resistive voltage divider. Make your measurements from the attenuator input to your circuit output. Be sure to measure the exact attenuation ratio at frequencies of interest.

5. We have said many times that open circuit time constants yield a conservative result for the bandwidth. In fact, it may not be possible to to make $\sum \tau_{jo}$ small enough to meet the bandwidth specification. A circuit that fails the OCT bandwidth spec by a small margin ($\sim$20%) will probably meet spec. That is why we use HSPICE to check our calculations and calculate a more exact result for the bandwidth. The point is to use the OCT method to optimize your design and get the best paper design you can before you go to HSPICE or go into lab.

6. HSPICE is not a design tool. It is only to be used to check your hand calculations. Do not run HSPICE simulations until you have fully analyzed your circuit (this includes open circuit time constants).

7. HSPICE is only as good as the model you give it. It doesn't have any information about the hybrid-pi model that you don't have. If the list of hybrid-pi parameters (under the "bipolar junction transistors subckt" heading) from HSPICE doesn't match your calculations exactly (within a few percent), then something is wrong with your model. Make sure that your capacitor values match exactly (including c_μ).

8. If you did poorly on Lab 1 (or turned it in late, or missed your check off) don't worry. Just do well on Lab 2. In the final grading analysis, Lab 2 will be worth twice as much as Lab 1.

9. Be sure to read anything written on the blackboard in the lab.

10. Please don't approach the staff for help unless you have fully analyzed your circuit (this includes open circuit time constants).

11. Reread the Lab Reference and the notes. Pay close attention to everything said in it about laying out your circuit, avoiding oscillations, and writing your lab report. You will be held responsible for all the material in the Lab Reference at your checkoff.

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