Review for Second Midterm

Midterm guidelines

The second midterm will be Thursday February 27th. You may bring one single-sided sheet of notes on US Letter paper. You may also bring a calculator, but please no complicated devices with stored equations. There will be around four questions taken from the topics we have discussed since the last midterm. I will try to provide some of the more arcane equations on the exam itself such as the JFET current equation, and the complex impedances of inductors and capacitors. Anything that you think you might need, however, you should probably include on your note sheet.

General Concepts

If you are still fuzzy about the concepts of transfer function, gain or attenuation in Decibels, or even KCL or KVL it would be good to refresh your memory. I won’t ask specific questions on these topics, but I do assume that you understand these concepts and you may well need to use these to solve the problems I do ask.

In particular, the idea of input and output impedance are critically important to a lot of the design issues in transistor circuits. Similar to what I have asked you to do in the labs, you should be able to describe specifically how you would measure either the input or output impedance of any arbitrary circuit. Remember, the basic idea is to find the relationship between $\Delta V/\Delta I$ either at the input or output of a circuit. For a linear circuit, this is simply $V/I$, but in general for a given operating point it is the derivative $dV/dI$ for a signal at some frequency, which we also can describe in terms of the AC characteristics $v/i$. Make sure you understand how to quickly determine input and output impedance for common circuits (particularly voltage dividers and transistor amplifiers).

Transistor circuits

Know the main BJT transistor circuits we have studied, including the emitter follower, common-emitter amplifier, current source (with load on the collector side), voltage source (with load on the emitter side), and differential amplifier. Know how to either analyze a circuit given to you or to design one of these circuits given a set of design parameters. I will give you a schematic showing all circuits on the midterm. Use the homework problems (and solutions) as a guide. Often the design process involves making reasonable assumptions. Understand what those are. For the common-emitter amplifier, be able to set up the base voltage biasing properly, including the effect of the emitter resistor in parallel with the lower leg of the input voltage divider (in other words, make sure $\beta \cdot R_E$ is large compared to $R_2$).

Understand the concept of input and output impedance in these devices, and be able to quickly find $Z_{in}$ or $Z_{out}$. Understand how a BJT has some “quiescent” or DC current flowing through it even when the input voltage is set to zero. Understand how this quiescent current sets the DC operating point for a transistor circuit, and can limit the AC performance. For example, remember that a BJT can not drive an output voltage past the supply voltage levels, meaning that $V_{out}$ is best centered at a value like $V_{CC}/2$. Understand some of the details of amplifier design which we have discussed, like bypassing the emitter resistor with a capacitor to increase the gain.
Make sure you follow the basic idea of using AC voltages and currents to find the gain in transistors, which essentially boils down to \( v_B = v_E \) and \( i_E = \beta i_B \). Review the common-base amplifier homework problem if you struggled with this the first time.

You will not need to directly use the Ebers-Moll equation to solve a BJT problem, but you should be familiar with the expression \( r_e = 25mV/I_C \) and understand where this should be used. For example, you should understand why you can not get infinite gain out of an common-emitter amplifier by setting \( R_E = 0 \). Finally, make sure you understand the use of coupling capacitors, both at the input and output of a transistor circuit to accommodate the DC bias voltage. Understand how their capacitance (together with the input or output impedance) limits the frequency response of a circuit.

I will not ask you anything about Miller capacitance, or transistor feedback (bootstrapping).

**Field Effect Transistors**

Know the main equations governing the \( I_D = f(V_{GS}) \) behavior of FET devices, particularly in saturation mode when \( V_{DS} > (V_{GS} - V_\theta) \). I will only ask you questions on JFETs, not MOSFETs on this exam. Be able to construct or analyze a JFET current source, follower, and amplifier, with or without a source resistor. Understand how the “gain” of a JFET is actually given by the transconductance \( g_m \) and be able to find \( g_m \) from known JFET attributes (\( I_{DSS}, V_\theta \)) and the DC operating point of a circuit. Also, understand the transition between the linear and saturation regimes and how a FET needs more “headroom” than the equivalent requirement on \( V_{CE} \) for a BJT. I will not ask you a question involving a JFET in the linear regime, although you may need to know when a JFET is no longer in the saturation regime (i.e. to find the compliance range of a JFET current source).

**Operational Amplifiers**

Know the open loop and typical closed loop properties of an op amp. Be familiar with the basic op-amp circuits, including the op-amp follower, inverting and non-inverting amplifier, as well as variants of current summing circuits.

Know the golden rules of op-amp design, and be able to apply these to analyze circuits. Understand that the feedback acts to keep the inputs at the same voltage, and the inputs do not draw any current. Using nothing more than the golden rules, KCL, and KVL, be able to analyze a new op-amp circuit which you have never seen before. Also know how to approach a problem that has diodes in the feedback path, although if I do ask a problem like this, it will probably be rather simple.

Understand how reactive elements (like capacitors and inductors) can also be used in the common op-amp configurations to produce integrators, differentiators, and various filter circuits. Understand how the DC gain equations for inverting and non-inverting op-amp circuits can also be used to find the frequency-dependent transfer function for circuits involving general impedance (capacitors and inductors). Any problem I give you with reactive elements will use one of these standard circuit configurations. Make sure you can plot the frequency response of a circuit in a Bode plot once you have calculated the amplitude transfer function.

I will not ask you any questions about the general feedback theory description of op-amps, or other non-ideal characteristics related to input bias current, finite gain, slew rate, or output current compliance. I might ask a simple question about input impedance into an op-amp circuit, looking for an approximate answer based on ideal op-amp behavior and finding the ratio \( V_{in}/I_{in} \).