Lab Goals

The goal of the lab is to give you the opportunity to design and demonstrate an analog FET circuit of your liking. In the process, you are expected to learn about the relevant concepts yourself and design and build the circuit. The staff will try to help wherever possible. This lab is about tinkering and not about writing long reports.

The lab is open-ended. This means that you can design and demonstrate any circuit that meets the following requirements:

i) The circuit type is not covered in any of the previous labs.
ii) The circuit is of sufficient complexity (e.g. simple CS, CG, CD stages will not do).
iii) The circuit makes use of the concepts used in this course.
iv) The circuit can be assembled from the components and chipsets available in the 3150 lab or in the ECE Maker lab. Resources in the ECE Maker lab will be available (to a certain degree) should you need them. You will need to contact Bruce Land for these resources.

Teams: You can work in teams of not more than two.

Requirements and Deliverables:

Project Proposal (Due between 04/25 to 04/30):

Submit a powerpoint proposal (3 slides max) of the circuit that you or your team would like to build. The proposal should include the following:

i) Project title.
ii) Names and net-IDs of the team members.
iii) A labeled schematic of the circuit (not hand-drawn). This is meant to be a preliminary schematic. You are expected to modify, improve, and change it as you work through the project.
iv) A brief description of the circuit (what it does, how it works, etc).
v) Values of the components (resistors, biasing currents, etc) and design parameters are not required in the proposal.
vi) Provide a listing of the quantities and specs you will measure and demonstrate in the lab in order to show that your circuit works as desired. For example, for an amplifier these specs could include gain, CCMR, maximum output swing, gain bandwidth, etc. For an RF oscillator, these specs could include maximum oscillator frequency, frequency tunability, maximum output voltage swing, linearity (maximum harmonic suppression), etc.
vii) Predicted spec values or any calculations are not required in the project proposal.
Your proposal would need to be **approved** by a senior member of the course staff (*Robin, Shimin, Farhan or RSF*) before you should start working on it. The **approval process** can work in two ways:

1) The preferable way is to sign up for a 10 minute slot to present your proposal (via a powerpoint presentation) to the course staff on 04/25, or on 04/27, or on 04/30 between 4:30 PM and 7:00 PM. The signup sheet is at:

   [http://signupschedule.com/rcy22](http://signupschedule.com/rcy22)

   This way the staff might be able to catch your major errors and/or offer suggestions for improvements and you will get the opportunity to discuss your project with the course staff. You must submit via email the proposal to the course staff (*RSF*) before the meeting time for which you have signed up.

2) The less preferable way is to just email a copy of the proposal to any one of *RSF* for approval (on or before 4/30) without signing up for a meeting with the course staff. Be sure to inform *RSF* that you will not be signing up for a meeting. If you decide to go this way, you will not get the opportunity to have a one-on-one discussion with the course staff about your proposal. The course staff will try to get back to you in a day or two with an approval (or a rejection with suggestions).

   Although, the last day of proposal submission is 04/30, the sooner you do it the more days you will have to work on building the circuits.

   The proposal approval process will look at the intellectual merit of your submission, feasibility, and relevance.

**Lab Work (04/25 to 05/9):**

After your proposal has been approved, you will build the circuit in the lab, measure the specs, demonstrate that things work close to what was intended, make changes as needed, and, most importantly, record the data that you would like to include in the final report.

**Lab Schedule and Support:** You can work on this lab during the regular ECE 3150 lab hours (or outside of the regular hours as permitted by the TAs) on any day of the week, and spend as many hours/days on it as you like. You can also work on Thursdays. Your circuit board will be kept in a safe place in the lab so that you can continue working on it over multiple days. Lab benches will be available on first come basis regardless of your scheduled lab day. **Always put away your circuits when you are not working actively at the lab bench to accommodate other students. And keep things tidy and clean – that means clean up after yourself (or your team will lose its off-hours lab access privileges).** Try not to send emails to course staff for lab help – rather seek help during the official lab hours. TAs will try to open the lab on weekends if there is enough demand.

Note that since the lab is open ended, TA support would be limited. Please don’t expect that the TAs will always know how to debug or redesign your circuit given the open-ended nature of the design project. You will need to take ownership of your design project.

**Mid-Project Feedback:** We realize that it is not always that easy to get hold of course staff. So the course staff will announce time slots to have one-on-one meetings with the staff with a sign-up sheet so that you get the opportunity to discuss your progress, challenges encountered, and get feedback.
Lab Demonstrations (05/07 to 05/9):

This lab demonstration will be made to the course staff (RSF) during the official ECE 3150 lab hours during the last few days of the classes. There will be a sign-up sheet for scheduling your demonstration. During the lab demonstration, you will show the working of your circuit, demonstrate key parameters, and answer questions about the operation of the circuit. Each question will be addressed to one member of a team, alternately. Your final score on the design project will depend on the quality of the lab demonstration and on your team’s ability to answer questions. Your lab project will then be checked-off by RSF.

Project Report Submission (Due 05/09):

Your final project report (to be submitted soon after project check-off) will consist of 2-pages (max limit) consisting of the following:

i) Project title.
ii) Team member names and net-IDs.
iii) Name of the course staff person (RSF) who approved the project proposal and the name of the course staff person (RSF) who checked-off the lab demonstration of the project.
iv) Final circuit schematic (not hand-drawn) including the actual values of all the components used in the final design used during lab demonstration.
v) A description of the circuit (what it does, how it works, etc).
v) Most Important: A documentation of the specs measured in the lab in order to demonstrate how well your circuit worked. You will need to record data, take pictures, plot curves, etc, and include these in your project report. Your final score on the design project will depend on the quality of the final project report.
vi) The report should be typed and not hand-written.

Note: The project report is intended to be this small so that you spend time designing and building and not writing long reports.

Extensions:

Try to finish all lab work by May 09. Extensions are possible but they will take away from the time needed for final exams preparations.

Grading Policy:

This design project weighs around 10% of your total course score (and included in the 35% specified for labs and homeworks). In addition, your score on this project will count heavily towards the points associated with instructor discretion in this course.

The score on this project will depend on its intellectual merit, difficulty and complexity level, quality of execution, results obtained and demonstrated during lab demonstration, ability to answer project related questions during the demonstration and check-off, and on the quality of the project report.

Grading is on a curve. So if you choose to work on something much more complex/difficult/original/etc than your colleagues, you will score higher in the intellectual merit/difficulty/complexity category. But you
also run the risk of being unable to deliver on the project. Having fall back options is not a bad idea for more ambitious projects.

Copying a circuit from online resources, book, paper, etc, for this project is completely allowed - as long as you can answer questions about its operation during the project demonstration. It will look really bad if you don’t know how the circuit works.

**Example Projects:**

Some examples of projects are (from last year’s projects):

i) Differential amplifiers with current mirrors  
ii) Multi-stage differential amplifiers (cascade, folded cascode, etc)  
iii) Fully complimentary differential amplifiers  
iv) Complete small opamps  
v) Complete small opamps operated with negative feedback  
vi) Wide bandwidth RF amplifiers and characterization of their frequency performance  
vii) Designs for minimizing harmonic distortion in amplifiers  
viii) Voltage mixers or multipliers or modulators  
ix) RF oscillators (differential pair, Colpitts, Clapp, etc)  
x) RF antenna communication links (transmitters, receivers, or both)  
x) Active filters using differential amplifiers

**Resources:**

Some online places that you might (or might not) find relevant for exploring project ideas are as follows:

**Warning:** There is way too much information here than what you will probably be interested in. So use these resources as you would use any internet resource (keeping in mind that there is no guarantee of correctness and/or accuracy).

1) Analog Zoo:  
This website covers all types of circuits and again is often very thorough in its descriptions. It is also nice because there are a lot of resources included should people want to go deeper.

2) CMOsedu  
This guy has videos on just about every type of analog IC design imaginable and in depth that is hard to find elsewhere.

3) Texas Instruments’ extensive literature. Example,  
[https://focus.ti.com/lit/an/slod006b/slod006b.pdf](https://focus.ti.com/lit/an/slod006b/slod006b.pdf)  
Texas instruments puts out a lot of literature that is usually fairly well written. The examples above are about basic opamps, among other things. A small differential amplifier may be substituted in many opamp
circuit examples (e.g. in active filters) but with due care (gain might not be what is required to make the circuit work).

4) Analog Devices Inc.
Educational literature from Analog Devices Inc.
And they also have labs too:
https://wiki.analog.com/university/courses/electronics/labs