EEE313- Lab Projects

You are provided with the 4 project options as specified below. You are expected to choose one of the projects and present a functional prototype. We are not looking for the best optimal performance for the projects, understanding the fundamental operation and showing a functional circuit meeting the specs will be enough. You can propose a different project, but the project needs approval from the course instructors. For example, a simple audio amplifier will not be approved. The project needs to employ a transistor as an analog amplifier and should have a unique aspect compared to the given projects for approval.

The projects will consist of 4 major parts with the specific deadlines:

1. Group and project declarations by 30th of November
2. Functional spice model of the circuit by 10th of December
3. Demonstration of the circuit on the breadboard by 17th of December
4. Printed circuit board implementation by 24th of December

You should submit a final report by 3rd of January that summarizes your design and measurement results. These projects will take some time and effort, and the timeline is tight so please start immediately. You can use BJTs or MOSFETs for the projects. PCB design materials will be provided later.

Each group will be assigned to a TA and the group will communicate with the TA about the project discussion and check points. Lab attendance is not mandatory, but lab times provide convenient time slots for everybody's schedules.

The grading of the project

- 20% spice simulation
- 50% breadboard and PCB implementation
- 30% report

Each group submits one report and gets the same report grade. Students will be graded individually for the spice and implementation parts. You will show a single spice and implemented circuit.

You can implement the project as 2 student groups. Please submit your project selection and your group to Moodle. We will open a submission tool in Moodle. You can pair with students from different sections. It would be more difficult, but you are welcome to do the project single if you wish so.

1. Discrete OPAMP

The goal of this project is designing a simple Operational Amplifier (OPAMP). The OPAMPs that you use in the labs are very complex, they consist of multiple transistors, have advanced biasing circuits, are low noise, are frequency compensated for stability, have output stages to deliver descent amount of current to a load. In this project you will design an OPAMP with self-biasing, differential input and single ended output, and an output stage.

The fundamental specifications are

- Dual power supplies (+/- V_{DD}) no more than +/-10V.
- Power consumption should be less than 200mW, i.e., <10mA total current per supply
- $A_V=v_{out}/(v_+-v_-)>500$.
- An output stage that can drive $R_L<1k\Omega$. The gain should not drop when R_L is connected.
- Resistors are allowed but you can get much higher gains with transistors.
- The circuit should generate its own biasing, if you need different voltages you should generate them from the supplies.
- Frequency compensation is not required, but you can implement it if you want to.

Note that these are the minimum requirements, if you can do better it is appreciated.

Your circuit will be tested as shown in Figure 1, + terminal will be grounded, $R_1=R_2=5k\Omega$, and $V_{out}=-V_{in}$ should be observed.

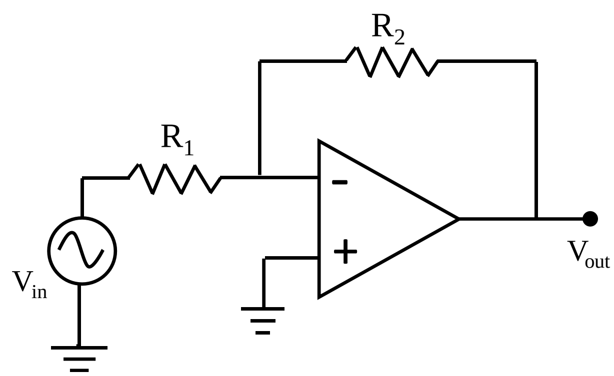

Figure 1: Test circuit for the OPAMP

2. Analog Multiplier

The goal of this project is designing a multiplier that would multiply two sine waves. Gilbert Cell is the most commonly used analog multiplier. A sine wave is added to the gate or base of the bias generator of the differential amplifier. The quiescent current of the input transistors then changes sinusoidally, i.e. g_m is not fixed but varies sinusoidally. The differential output is $g_m v_d$, since both of them are sine waves, multiplication is achieved.

The fundamental specifications are

- Dual power supplies (+/- V_{DD}) no more than +/-10V.
- Power consumption should be less than 200mW, i.e., <10mA total current per supply.
- Resistors are allowed.
- The circuit should generate its own biasing, if you need different voltages you should generate them from the supplies.
- A double balanced mixing cell is required.

Given 1kHz and 20kHz sinewaves the output of the circuit should be the multiplication of these two signals. This is an AM modulator, you will receive full credit if you can show an AM modulated signal.

3. Transistor-based Sinusoidal Oscillator

The goal of this project is to design and implement a a transistor based sinusoidal oscillator at 1 MHz. Look at Section 15.2 of Neamen 4th edition to learn the theory of analog oscillators. There must be a frequency fine tuning circuit (use voltage-controlled varactor based tuning) and also a second stage (a filter stage) which decreases harmonic distortion. You may use any one of known transistor-based oscillator topologies.

4. Sample and Hold Circuit

The goal of this project is designing a demodulator. Sample and hold circuit performs demodulation. You can simply think of demodulation as finding the amplitude of a sine wave. Figure 2 shows the sample and hold circuit operation. The input sine wave is sampled at the peak points and stored on a capacitor. The capacitor voltage is buffered and provided as an output. As a result, magnitude of the input sine wave is obtained. The buffer can be realized with amplifiers covered in the classroom. A MOSFET can be used as a switch. The most critical part of this project is generating $V_{control}$ for the switch from the input. You might need another buffer between the input and the switch.

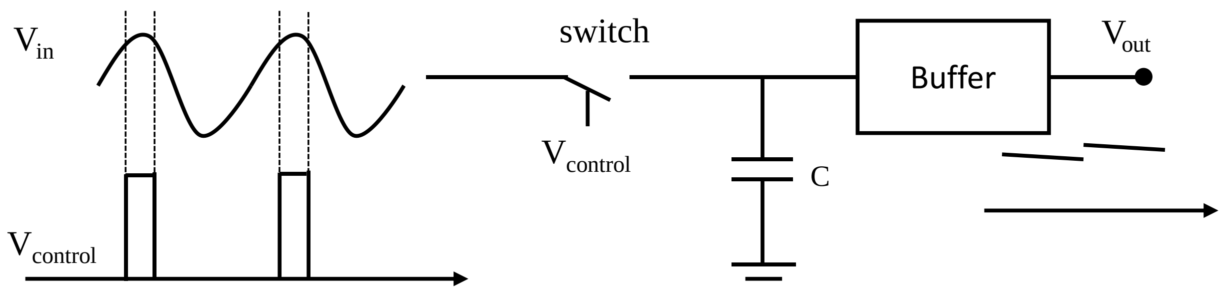

Figure 2: Sample and hold circuit

The fundamental specifications are:

- You should generate $V_{control}$ from V_{in}. You can use an FPGA, microcontroller or an external IC to generate $V_{control}$. Note that if $V_{control}$ and V_{in} are not synchronized you will not be able to sample the signal at the peak points.
- You can make your switch or buy an off the shelf switch.
- The buffer must be implemented with transistors.
- You will be given maximum of +/- 10V power supplies, you should generate your own biasing from the supplies.

Your circuit will be tested by providing a sine wave and your circuit output should linearly change with the amplitude of the input sine wave.