EE 16B Designing Information Devices and Systems II
Spring 2019 A. Sahai, J. Roychowdhury, K. Pister **Project Note 1**

Project Part 1: Front End

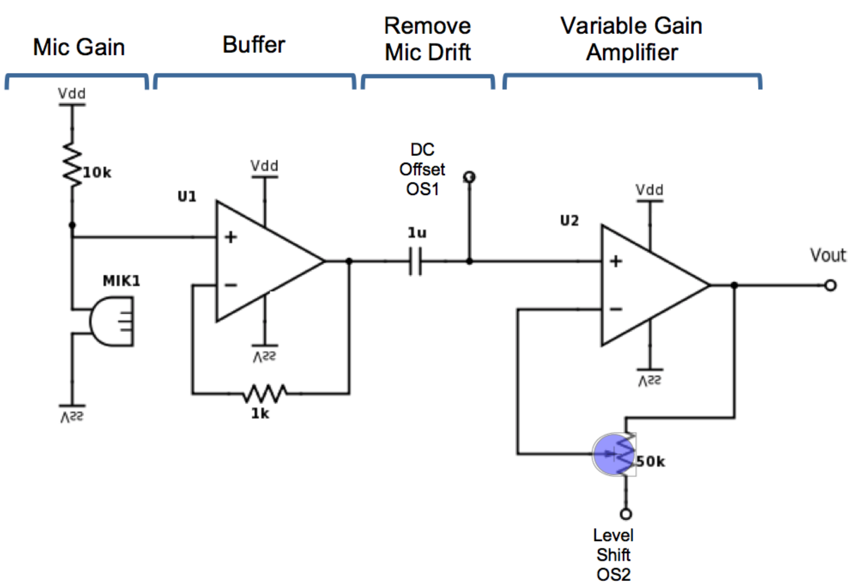
For the rest of this semester you will be designing SIXT33N, a mischevious little robot who *might* just do what you want - if you design it correctly. In this phase, **you will be desiging SIXT33N's ears**: a microphone front end circuit that processes the mic signal into something you can record using the Launchpad ADC.

The goals of this phase are as follows:

- Band pass filter circuit
- Level shift + gain circuit for ADC
- View ADC output on PC
- Record data for next phase
- Prepare to use batteries to power SIXT33N

Part 2: Microphone Biasing Circuit

Our biasing circuits will provide signals for the OS1 (DC Offset) and OS2 (Level Shift) pins of the mic board. Before we build the biasing circuits, let's take a closer look at our mic board. The mic board contains the following circuit:



- **Microphone Gain:** The electret microphone behaves as a *variable current source* depending on the size of the sound waves hitting it. Current signals are generally more difficult to work with than voltage signals, so you will turn that into a voltage signal using the Mic Gain part of the circuit.
- **Buffer:** This buffer helps keep the amplifier and the capacitor from affecting the microphone (see Note 4 for a review of loading). It looks a little different from the buffers we usually use (there's a resistor in the feedback loop), but it functions just the same.
- **Remove Mic Drift:** A capacitor placed between one circuit stage and the next is usually called a coupling cap, but it really just a high pass filter with a very low cutoff frequency. The microphone naturally has a lot of low frequency drift, so we use this coupling cap to remove any DC offset and noise. This allows us to ignore whatever DC value the mic gain stage had, and add in a suitable DC value in the next stage.
- **DC Offset:** For this project, **you will not have a negative power source**, only your 5V rail and ground (since the Launchpad cannot take negative voltage inputs). If you center your signal around ground, like we did in previous labs, then you will lose the negative half the signal as soon as you send it through the op-amp because

your op-amp won't be able to supply those negative voltages (since it is supplied by ground and either 5 or 3.3V). To get around this problem, we want to center our signal in the center of our available voltage range.

However, you will have to be careful and remember that a DC offset exists or it could become troublesome. Think of a 0.1V DC signal. Now put that signal through a non-inverting op-amp with a gain of 100. Suddenly that 0.1V DC signal becomes 10V!

- **Level Shift:** When we introduce the DC offset at OS1, we have to adjust our amplifier to expect signals centered around that offset. We will explain this further in the next part.
- **Amplifier:** Finally, the mic board uses a non-inverting amplifier to amplify the microphone signal. Note that OS2 is on the inverting terminal of the op-amp - we can use this to help us deal with our DC offset problem.

Now, let's move **off** the mic board and focus on our biasing circuits.

- **OS1: DC Offset**

  Because we need our signal to be centered in our usable range (0 - 3.3 V), we will need to set the DC offset to the midpoint of this range: 1.65 V. This can easily be accomplished with a voltage divider of two equal resistors from the 3.3 V rail to ground.

- **OS2: Level Shift**

  When we introduce the DC Offset, we will encounter a problem when the signal passes through the non-inverting amplifier: that DC offset will be amplified along with the rest of the signal! This is because the amplifier will amplify the signal as referenced from *ground*. This is the key problem here.

  If we want to avoid amplifying the DC offset, what value should we use for the reference?

  If you guessed 1.65 V, congratulations! This is the key idea to a level-shifter.

  Recall that we connected OS2 to ground when we built color organ - this is how we told the non-inverting amplifier to use ground as a reference. To use 1.65 V instead, **we will need to connect OS2 to a non-zero voltage**. This voltage will need to match the DC offset we introduce to OS1.

  However, we have another problem: our resistors can vary by up to 5%. This means it will be very unlikely that we can find two matched pairs of resistors so both OS1 and OS2 will be at exactly the same voltage. To overcome this issue, we put a buffer between the OS1 and OS2.

  You are now ready to start Part 2! Go to the Jupyter Notebook and complete the rest of the lab.

References

Original Project Part 1 notebook written by Nathaniel Mailoa and Emily Naviasky (2016).

Notes written by Mia Mirkovic (2019)