Lab 6 – Notes

Spring 2024

JOHN GERGUIS

General Notes

- Make sure to use your ESD wristband at all times when using the ALD chips.
- Each student is encouraged to begin building her/his own version of the opamp for the lab practical.
- **Please leave your circuit built for lab 7 and the practical, it's the same circuit.**

Task 1

Task 6.5.1: Multi-branch current mirror

You will need various current mirrors to build the circuit shown in figure 6.3. In this task, you will pre-construct those mirrors using temporary resistive loads. As you work through the experiment, you will replace each resistive load with a relevant amplifier.

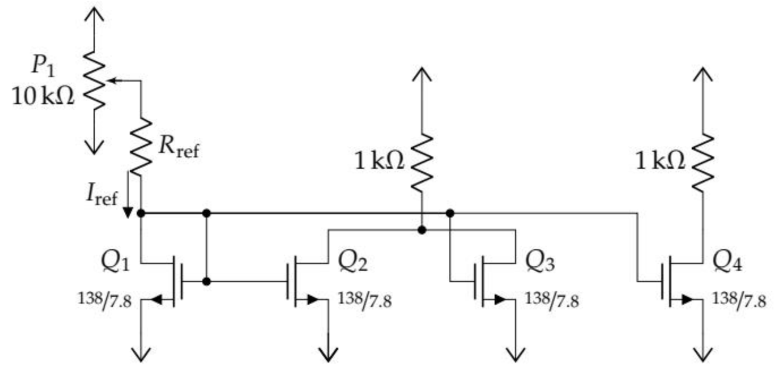


Figure 6.9: Multi-branch current mirror with 4 NMOS.

1. *Build* the current mirror shown in figure 6.9 and *set* the reference current to $I_{REF} = 200\,\mu A$ by adjusting P_1.
2. *Measure* the resulting current through the two branches. What are the percent errors?
3. What are the possible sources of error in the current mirrors?

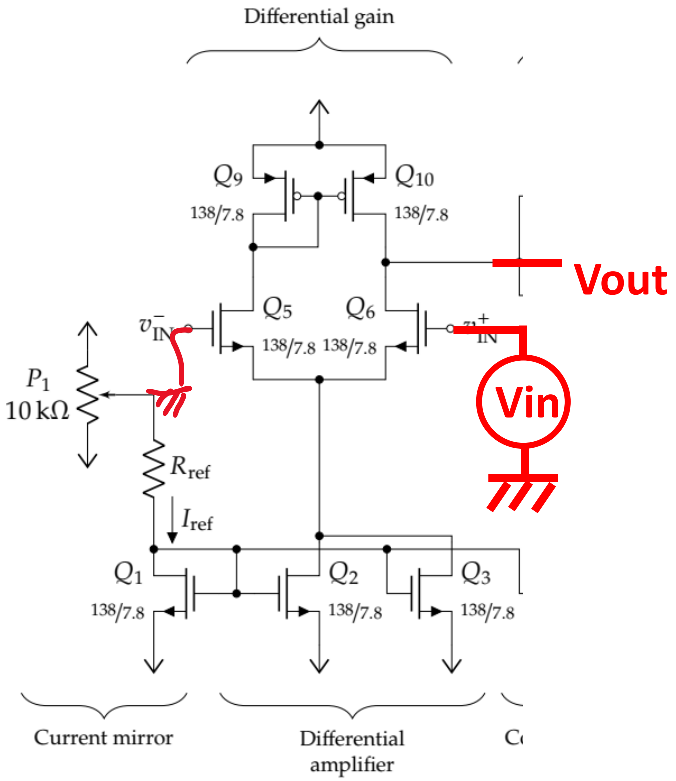
*Leave this circuit built for the next tasks

- Use ALD1106 for this part.
- This is the same as the previous labs, we are building one current doubler branch (Q2//Q3) and one current mirror branch (Q4).
- Measure the current and comment

Task 2

Task 6.5.2: First stage: Active load differential amplifier

1. *Build* the differential amplifier with an p-channel MOSFET (PMOS) mirror active load from figure 6.3, using the 2 : 1 current mirror branch. Make sure to remove the temporary resistive load.
2. *Measure* the single ended gain using a 0.01 sin $(2\pi 100t)$ signal applied to v^+_{IN} while connecting v^-_{IN} to ground.



*Leave this circuit built for the next tasks

- Use ALD1105 for the diffamp.
- Make sure to remove the 1kΩ resistor before adding the diffamp.
- This is the same as the circuit in lab 5, task 3. The only difference is that the inputs are swapped, so the output sinusoidal will be inverted with respect to the input.

Task 3

Task 6.5.3: Second stage: Common source amplifier

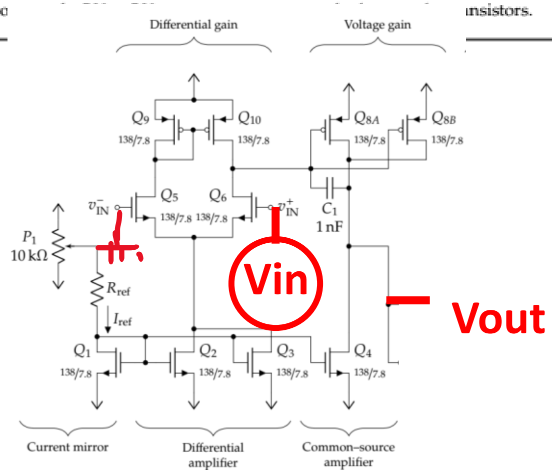
1. *Estimate* the gain of the common source amplifier used as the second gain stage in figure 6.3 using the actual current measured in task 6.5.1.
2. *Estimate* the overall open-loop gain from the first two stages using the measured gain in task 6.5.2.
3. *Build* the common source amplifier from figure 6.3 using the 1 : 1 current mirror branch. Make sure to remove the temporary resistive load.

Previous techniques to measure amplifier's open-loop gain are now very difficult to apply. This is because the open-loop gain, A, is quite large, thus, even minute changes on the input produce large changes at the output. In practice this is not an issue because op amps are normally only used in circuits with negative feedback networks.

In lieu of measuring the open-loop gain, we will use the input stage of the op amp as a comparator. A comparator exploits the op amps large gain to output a constant voltage based on whether v_{IN}^{+} or v_{IN}^{-} is larger. It is important to note that if you need a comparator in a project, use an integrated circuit (IC) specifically designed as such.

3. *Apply* a DC threshold voltage of 0 V to v_{IN}^{-} by grounding it.
4. Using the function generator, apply a DC voltage between −2 V to 2 V[a]. *Adjust* the value and observe the output. *Explain* what the comparator circuit is doing.
5. *Record* the input and output for a positive input voltage.
6. *Record* the input and output for a negative input voltage.
7. *Change* the input voltage to be a $2\sin(2\pi 100t)$ V signal.
8. *Plot* the input and output. *Explain* the shape of the output.

[a] Be sure not to … ansistors.



*Leave this circuit built for the next tasks

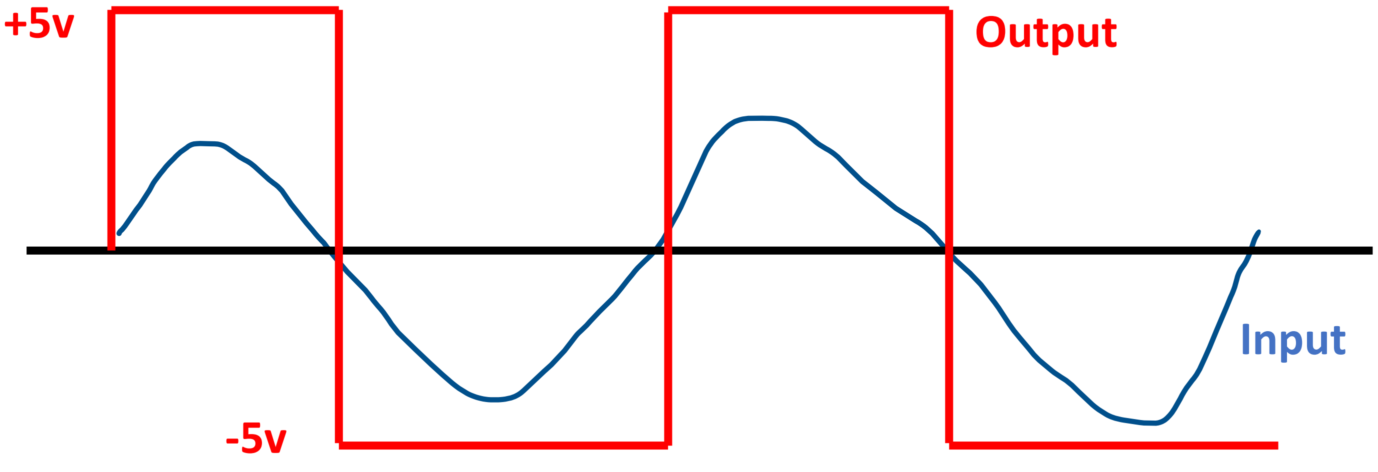
1. $A_v = g_{m8}(r_{op8}//r_{on4})$. Note that Q8 is (Q8A//Q8B), thus it has 2(138/7.8). Use your measured Iref to calculate the gain (gm and ro are function in the current).

2. $A_{Total} = A_{diff}(measured\ from\ task\ 2) * A_{CS}(calculated\ from\ the\ previous\ step)$.

3. Build the CS amplifier using the last branch (after removing the 1 kΩ resistor). Use the ALD1107 for Q8.

3->6. Measuring the open loop gain. Put a DC voltage at the input (vin+). Try different +ve & -ve DC values at the input. What happens at the output? What is the comparator circuit doing?

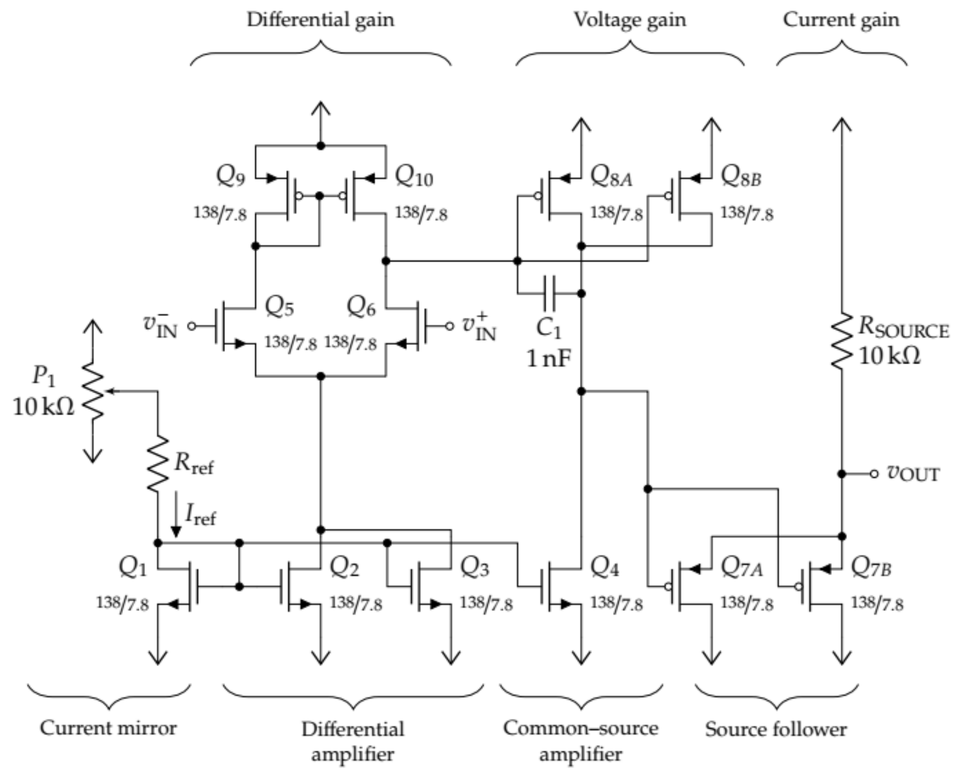
7/8. Replace the DC voltage by a sinusoidal signal and measure the output. Comment on the output shape.



Task 4

Task 6.5.4: Third stage: Source follower

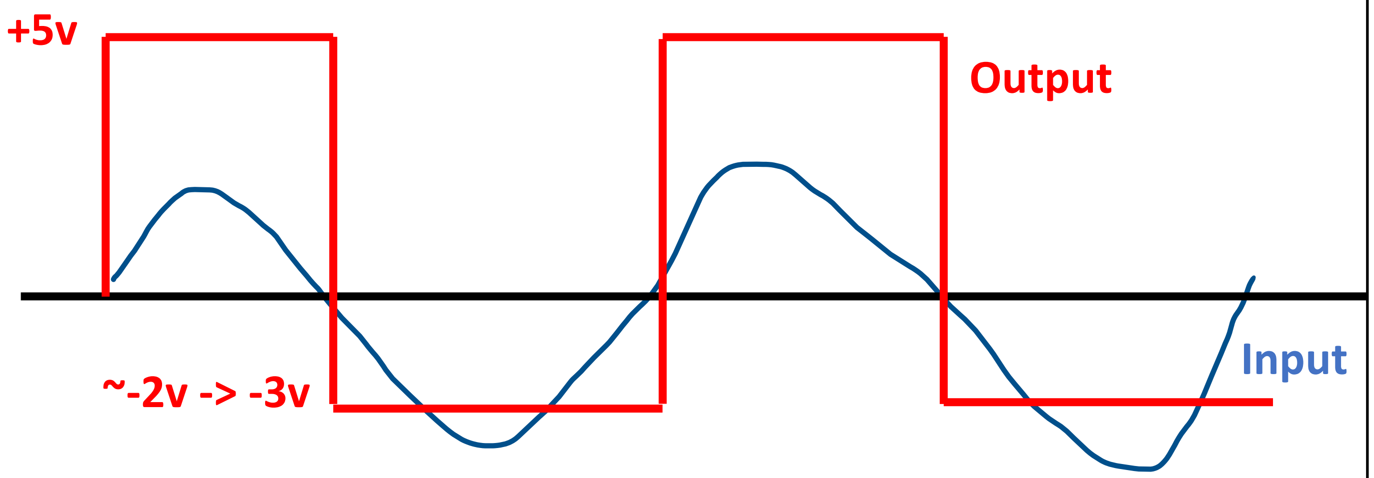
1. *Build* the common drain amplifier from figure 6.3.
2. Connect v_{IN}^{-} to ground and v_{IN}^{+} to a $2\sin(2\pi 100t)$V signal.
3. *Plot* the input and output and compare to the result in task 6.5.3.



*Leave this circuit built for the next tasks

- Use the remaining transistors on ALD 1107 for Q7.

2/3. This is should be similar to the output of the previous of the CS amplifier, the only difference would be in the output swing.



Task 5

Task 6.5.5: Inverting Amplifier

As a final exercise, test your op amp by building the inverting amplifier shown in figure 6.10 using the complete op amp circuit you built in task 6.5.4.

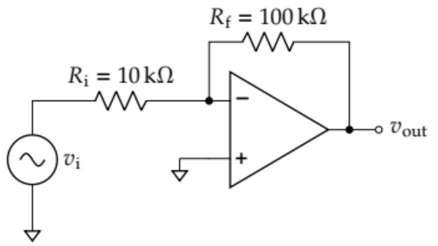
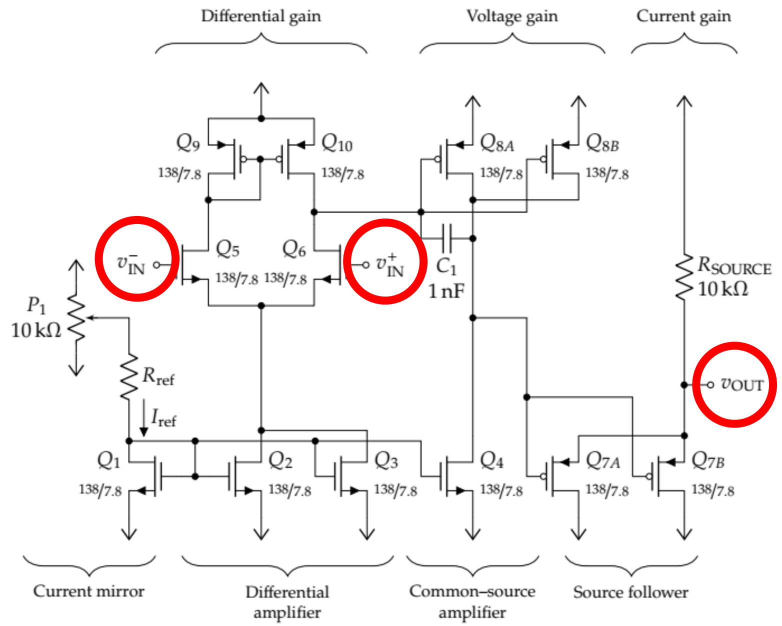


Figure 6.10: A gain −10 op amp based inverting amplifier.

1. *Build* inverting amplifier with gain 10 using the op amp from figure 6.3.
2. *Measure* the gain. What is the percent error?



- This opamp is your whole opamp circuit ☺

2. You need to put a sinusoidal signal at the input, then measure the output signal to compute the gain.

Which value should we use as an amplitude for the input?!!

We always need to make sure that the output signal is not distorted, and much less than the rail-to-rail voltage (+5 & -5). Maybe try to limit the output to be around 1-2 v. The input voltage then will depend on the gain of the circuit that we are building.

What input would be reasonable here?!!