Experiment 4 Report

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Abstract

In this experiment, an ALD1106 Dual matched pair n-channel MOSFET array chip is used to create a current mirror circuit and an inverting amplifier. In the current mirror application, the current can be set based on various voltages, as described and equated later in this document. The inverting amplifier can have a desired gain and frequency response, and these values can manipulate what voltages are needed where, and thus, what parts to use in the circuit. We were sucessful in creating both of these circuits, testing extensively, and evaluating our performance through mathematical and graphical interpretation.

Task 1

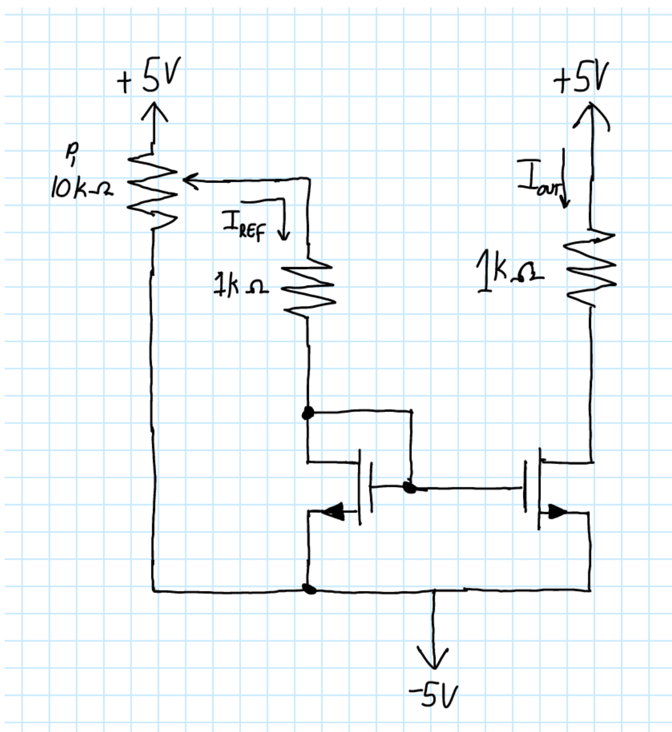
Objective

The objective of this task is to design and build a current mirror circuit using the ALD1106 dual matched pair n-channel MOSFET array.

Procedure

Step 1

The circuit below was built:



Step 2

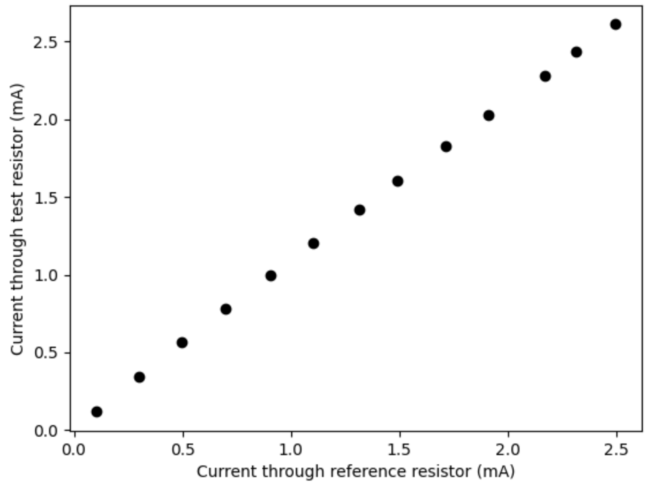
The current I_{OUT} was plotted against I_{REF} between $I_{REF} = 0.1$ mA and 2.5 mA. This was done by measuring the voltage across R_{REF} and R_{TEST} respectively, and computing the current through each using Ohm's law.

Step 3

The reference current was set to 1.34 mA, as calculated from prelab question 2. The gate-source (v_{GS}) and drain-source (v_{DS}) voltages were measured for each transistor.

Results / Calculations

Step 2 The following plot was created:



The plot shows that the current going through the reference resistor is very close to the current going through the test resistor, meaning the current mirror is working correctly. The average difference in current between the two resistors is 0.092 mA.

Step 3 The measured voltages from each transistor were:

Q1 (Left transistor) : $v_{GS} = 2.5897$V , $v_{DS} = 2.5899$V

Q2 (Right transistor): $v_{GS} = 2.5901$V , $v_{DS} = 8.5536$V

Conclusions

In this task, we created a current mirror circuit that matched the current from one transistor to another. This circuit worked very well, as shown by the plot of current values.

Task 2

Objective

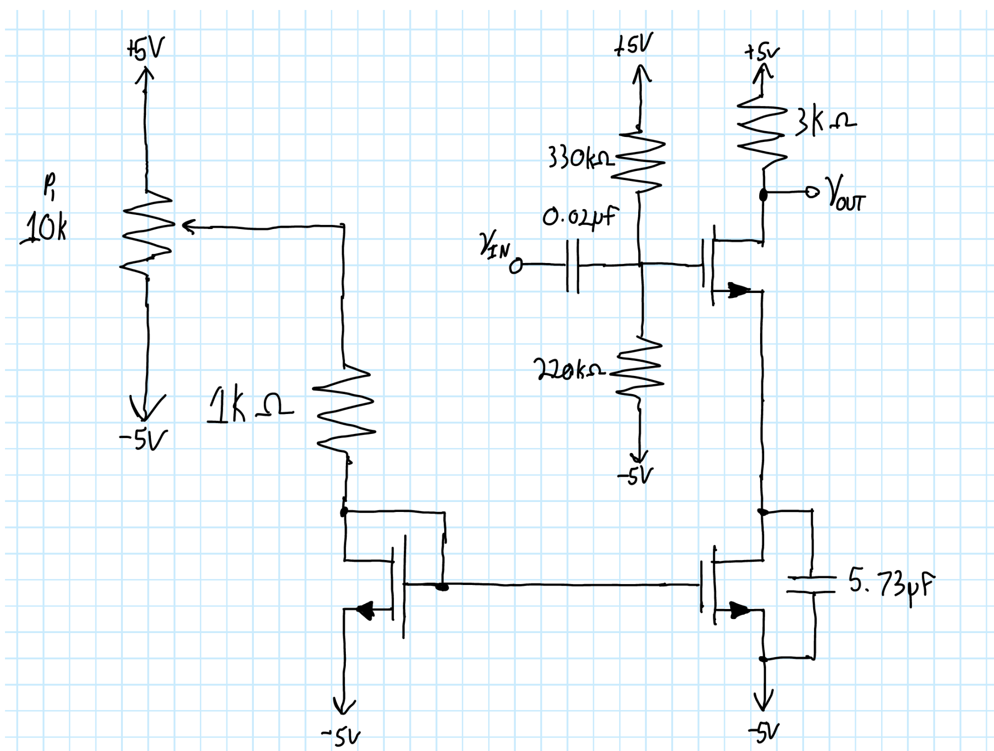
The objective of this task is to create an inverting amplifier with specifications determined in the lab manual.

Procedure

Step 0 (Prelab Question 2) The values of R_1, R_2, R_D, and I_{BIAS} were calculated such that the gain A_v is -4, the DC output voltage is around 1V, and the minimum output voltage was -1V. Additionally, R_1 —— R_2 must be greater than 100kΩ.

Step 1 The values of C_1 and C_2 were calculated such that the -3dB point of the frequency response would be at 30 Hz.

Step 2 The following circuit was built using the values calculated above:



Step 3 The AC input v_{IN} was set to 0V, and adjust the potentiometer so that the DC output V_{OUT} is around 1V, as per the design specification.

Step 4 The AC input v_{IN} was set to a 200 mV_{pp}, 500 Hz sine wave.

Step 5-7 An oscilloscope screenshot was captured showing v_{IN} on one channel, and v_{OUT} on another. The peak to peak voltages of each are shown, so that the gain A_y can be calculated.

Next, on the oscilloscope, a frequency response graph was created from 1Hz to 500 kHZ over 100 steps.

Step 8-10 The AC input v_{IN} was set to a $1V_{pp}$, 5kHz triangle wave.

The amplitude of v_{IN} was slowly increased until there was significant distortion displayed on v_{OUT}. The final signals were captured on an oscilloscope screenshot.

Results / Calculations

Step 0

Step 1

The capacitance for C_1 is calculated to be such that the filter cutoff is 30 Hz. This is done by the following equation:

$$f_{-3dB} = \frac{1}{2\pi C_1(R_1||R_2)} \tag{1}$$

which can be solved to:

$$C_1 = \frac{1}{f_{-3dB}2\pi(R_1||R_2)} = \frac{1}{30Hz * 2\pi * (330k||220k)} \approx 0.02\mu F \tag{2}$$

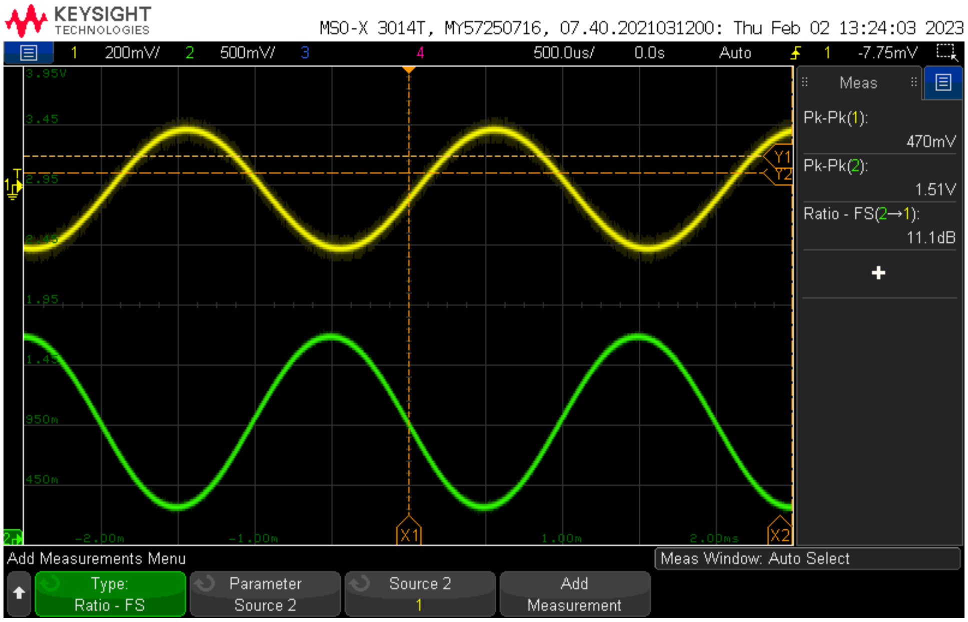
The equation for C_2 is calculated similarly thoguh the formula:

$$f_{-3dB} = \frac{g_m}{2\pi C_2} \tag{3}$$

which can be solved to:

$$C_2 = \frac{g_m}{2\pi f_{-3dB}} = \frac{-\frac{A_y}{R_D}}{2\pi f_{-3dB}} = \frac{A_y}{-2\pi f_{-3dB}R_D} = \frac{-4}{-2\pi * 30Hz * 3k\Omega} \approx 5.73\mu F \tag{4}$$

Step 5 The following is the oscilloscope screenshot showing v_{IN} and v_{OUT} with peak to peak voltage measurements.



Step 6 The voltage gain A_y is calculated using the following equation:

$$A_y = \frac{v_{OUT}}{v_{IN}} \tag{5}$$

which when used with the values measured by the oscilloscope,

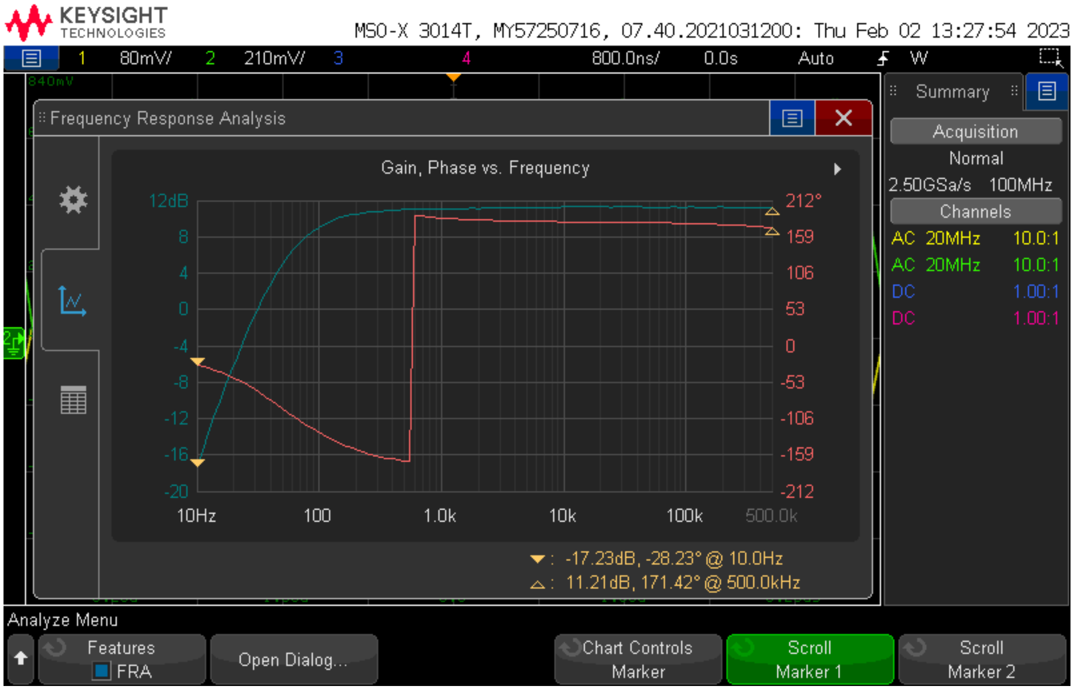
$$A_y = \frac{1.51V}{470mV} \approx 3.212 \tag{6}$$

with percent error:

$$\%error = \frac{measured - calculated}{calculted} = \frac{3.212 - 4}{4} \approx 20\%err. \tag{7}$$

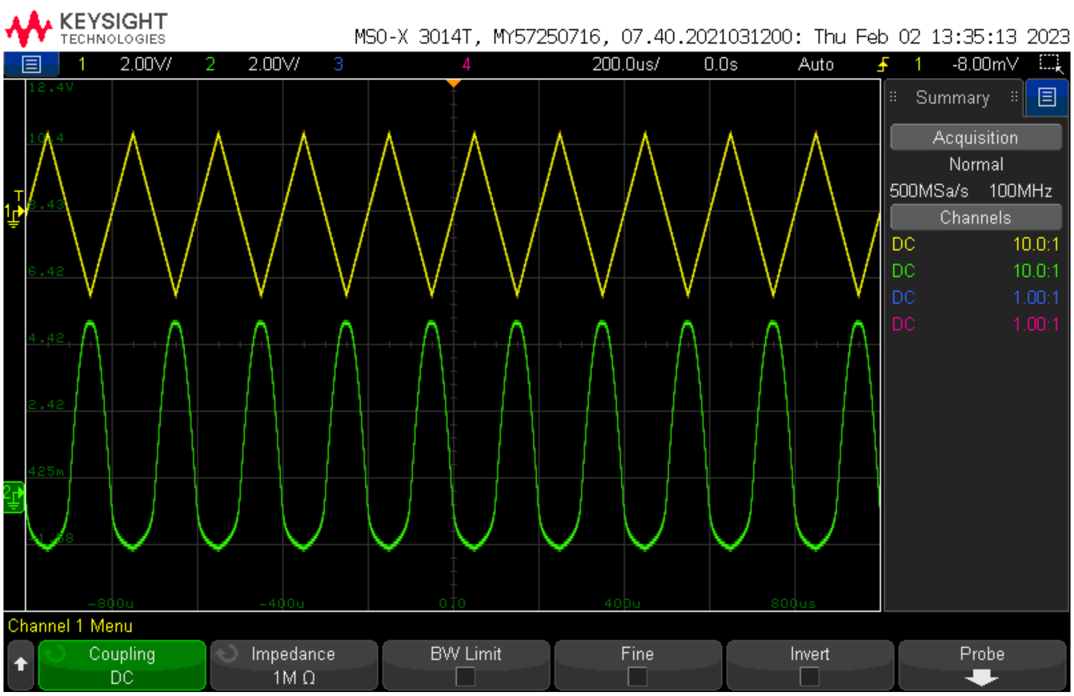
Step 7

The following is the frequency response analysis for the circuit between 1 Hz and 500 kHz.



Step 10

The following is the largest signal aplitude that resulted in little distortion to the input signal.



The input voltage shown is , which is approximately V above our design specification. Any signal larger than this experiences large distortion and clipping.

Conclusions

In this task, we created an inverting amplifier using the ALD1106 chip and its enclosed N-type transistors. We created the amplifier as per the design specifications, and had a working amplifier with very little error in our design choices.