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Section: 009

Lab: 04

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Abstract

The purpose of this lab was to demonstrate the fundamentals of a current mirror and how it is applied within an amplifier. An AD2 was used to generate waveforms, measure voltage, and visualize waveforms. The circuits were built on a breadboard using one ALD1106 chip. The unknown values of current and voltage within the current mirror were found. Afterwards, the current mirror was placed within an amplifier and the values for each capacitor, gain, and the largest signal that can be applied to the circuit without distortion were found. These two tasks were important in demonstrating how the circuits and theory actually apply to real life applications.

Task 1

Objective

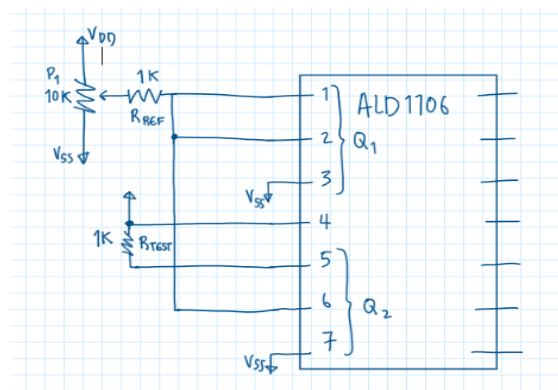
The objective of this task is to demonstrate how a current mirror is built, applied, and how to measure different values within it.

Procedure

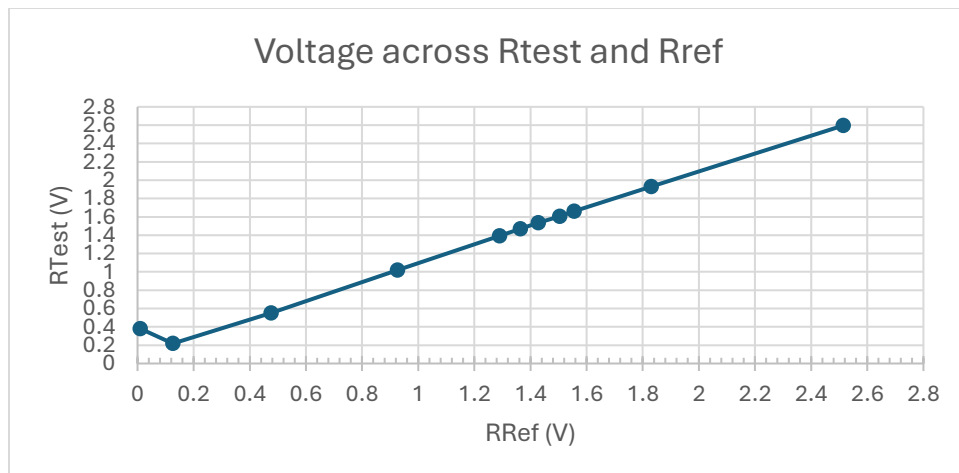
First, the circuit shown below was constructed. Using an AD2, the voltage across R_{TEST} and R_{REF} were measured. The I_{OUT} and I_{REF} were then found by dividing the voltage across R_{TEST} and R_{REF} by V_{TEST} and V_{REF} , respectively. Next, I_{OUT} and I_{REF} were plotted on excel to show how they related. Afterwards, the I_{REF} current was set to the one found in the prelab and V_{GS} and V_{DS} were measured for both transistors.

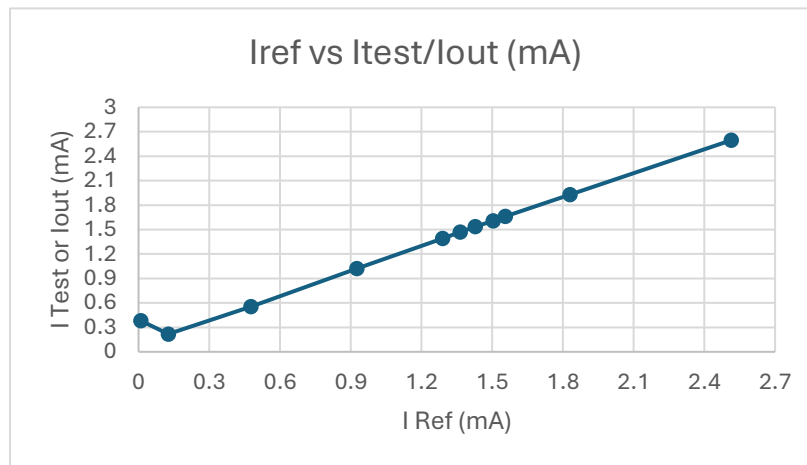
Results

Circuit



Plots





Measurements

v Rref	v Rtest	Rref (ohms)	Rtest (ohms)	I Ref (A)	I test (A)	I ref (mA)	Itest (mA)
0.01	0.38	1000	1000	0.00001	0.00038	0.01	0.38
0.126	0.218	1000	1000	0.000126	0.000218	0.126	0.218
0.476	0.552	1000	1000	0.000476	0.000552	0.476	0.552
0.926	1.02	1000	1000	0.000926	0.00102	0.926	1.02
1.29	1.392	1000	1000	0.00129	0.001392	1.29	1.392
1.364	1.468	1000	1000	0.001364	0.001468	1.364	1.468
1.428	1.534	1000	1000	0.001428	0.001534	1.428	1.534
1.504	1.606	1000	1000	0.001504	0.001606	1.504	1.606
1.556	1.66	1000	1000	0.001556	0.00166	1.556	1.66
1.83	1.93	1000	1000	0.00183	0.00193	1.83	1.93
2.514	2.596	1000	1000	0.002514	0.002596	2.514	2.596

Value from Prelab:

$$I_{REF} = 4.91\text{mA}$$

V_{GS} and V_{DS} at specified I_{REF}

	MOSFET 1	MOSFET 2
V_{GS} (V)	1.04	1.058
V_{DS} (V)	1.062	3.428

Conclusions

The task was successful since the current mirror was successfully built. There were some difficulties originally since we originally powered the ALD1106 with both V_+ and V_- , but once we sorted it out, the transistors worked as expected. The values for current and resistance were found and successfully plotted by applying the circuit and the values found in the prelab.

Task 2

Objective

The objective of this task is to demonstrate how a current mirror is applied and used within an amplifier. The task builds on the previous task to build on the previous knowledge.

Procedure

First, C_1 and C_2 were calculated so that each filter had a 3dB point lower than 30Hz. Using the found values from the prelab and the capacitors, the circuit was built using 1 ALD1106. The V_{in} of the circuit was set to 0 and the DC value of V_{out} was measured. Afterwards, the V_{out} value was set to 1V by adjusting the potentiometer. A screenshot was captured when V_{in} was set to be a 200 mV_{pp} 500Hz sin wave and the gain was found. Using the AD2, a plot of gain vs frequency was found. Next, the V_{in} was set to a 1 V_{pp} 5kHz triangle wave. The amplitude was slowly raised until it was distorted to find the largest amplitude with no distortion.

Results

C_1 & C_2 equations:

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

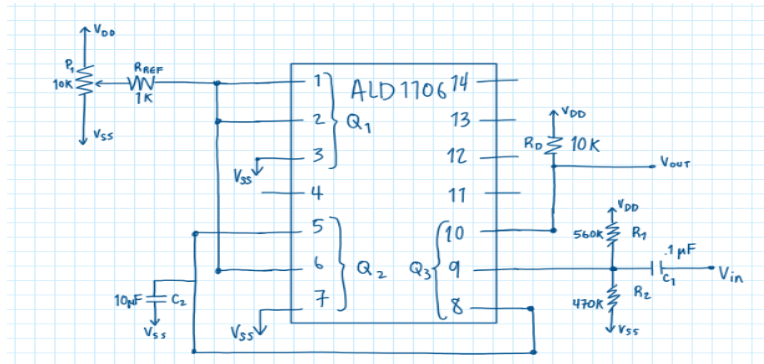
$$f_{-3dB} = \frac{g_m}{2\pi C_2}$$

These equations give us:

$$C_1 = .1\mu f$$

$$C_2 = 10\mu f$$

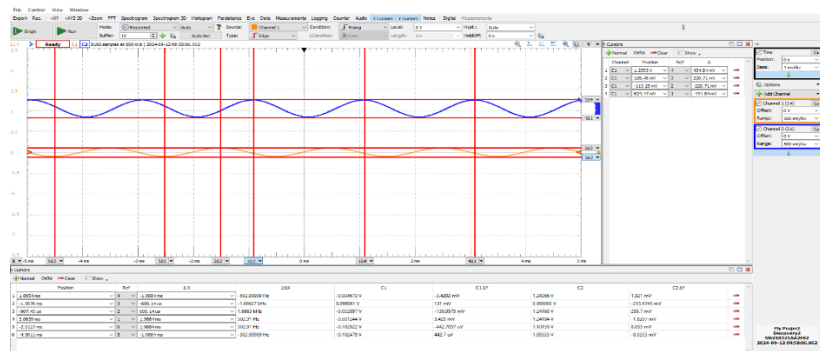
Circuit diagram



DC value of V_{out} :

$$V_{out} = 1.036 V$$

Screenshot V_{in} (ch1 / orange) and V_{out} (ch2 / blue)

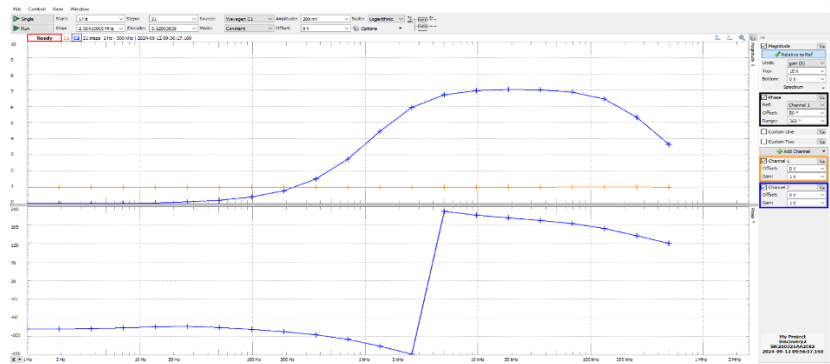


Gain

$$A_v = \frac{V_{out,pp}}{V_{in,pp}}$$

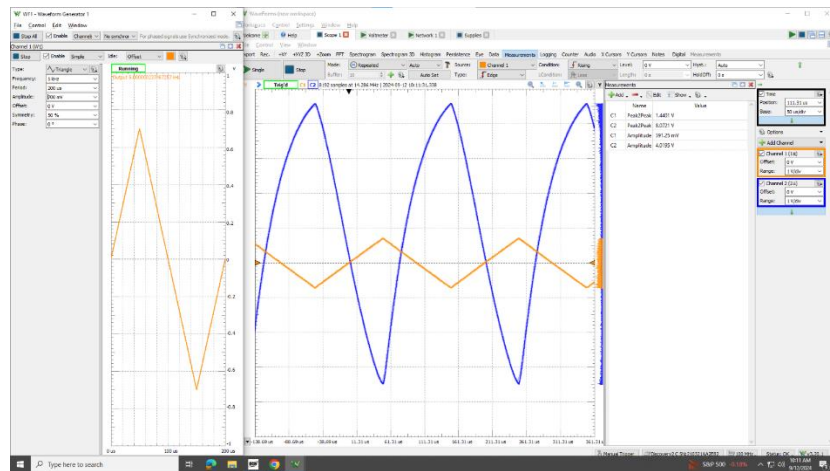
$$A_v = \frac{434.84 \text{ mV}}{220.71 \text{ mV}} = 1.970$$

Gain v frequency - Ch1 in ch2 out

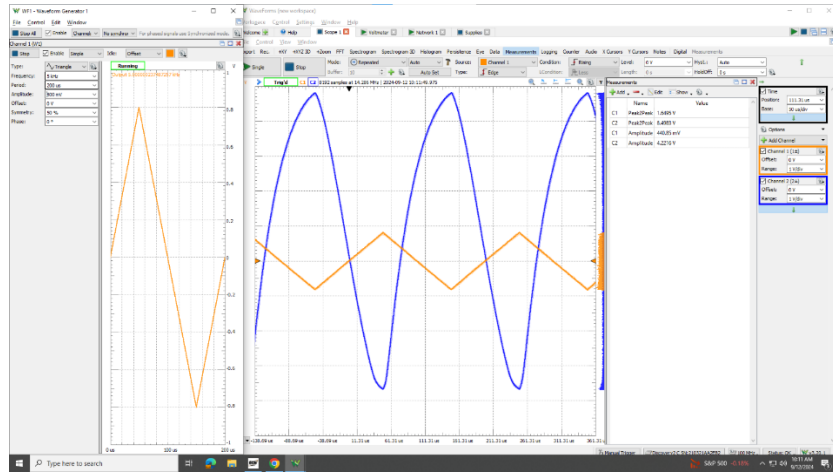


$1\text{hz} < f < 500\text{khz}$

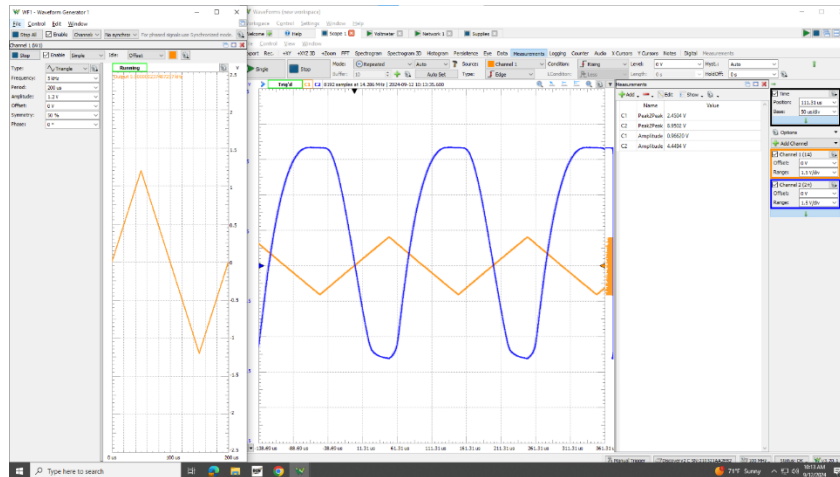
Distortion graphs:



No distortion (700mV)



Distortion (800mv)



Very high distortion (1.2V)

Conclusions

The task was successfully completed. The circuit was built by building upon the previous task's circuit, and it worked as intended. The gain was successfully found and the frequency response graph looked as it should. Finally, the maximum amplitude input without distortion was found successfully. The application of a current mirror within an amplifier was demonstrated.

References

<https://www.alldatasheet.com/datasheet-pdf/download/55017/ALD/ALD1106.html>

<https://www.youtube.com/watch?v=k85mRPqvMbE>