EE230: Lab 5
Photodiode &
Instrumentation Amplifier

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1 Overview of the experiment

1.1 Aim of the experiment

1. Creating and Simulating model for a Photodiode, finding the variation in V_{out} with I_1.

2. Creating and Simulating a model for an Instrumentation Amplifier, finding variation in V_{out} with V_{cm}, V_{i_1} and V_{i_2}.

1.2 Methods

The circuit diagrams for Photodiode and Instrumentation Amplifier were provided in the lab handout, using which I created and simulated them in NGSpice.

2 Design & Working

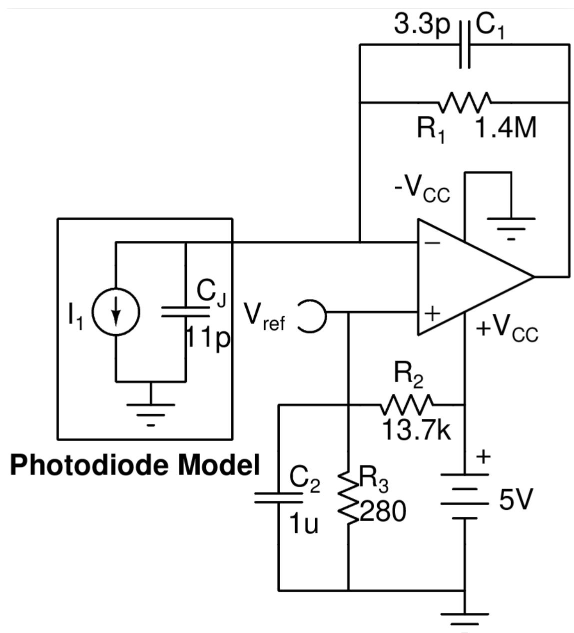


Fig. Photodiode

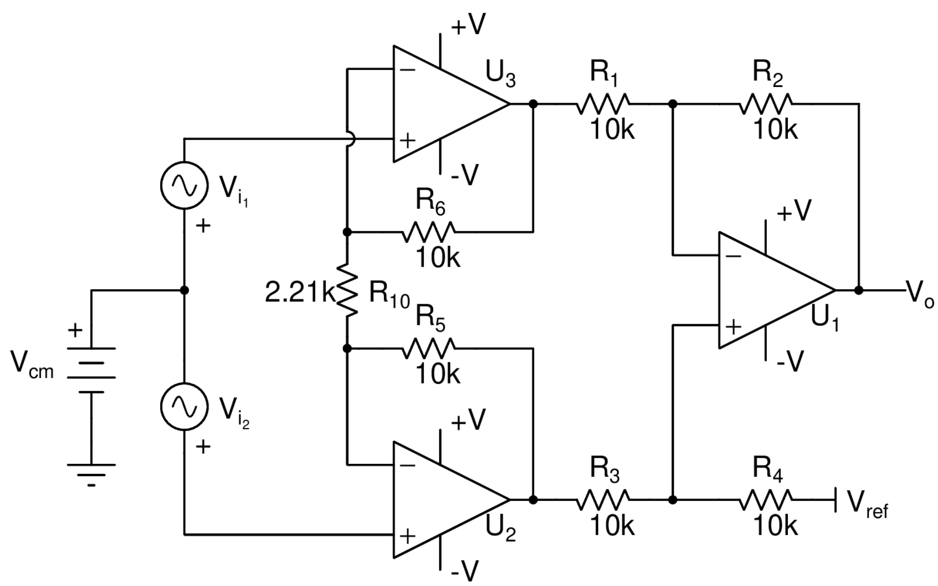


Fig. Instrumentation Amplifier

3 Simulation results

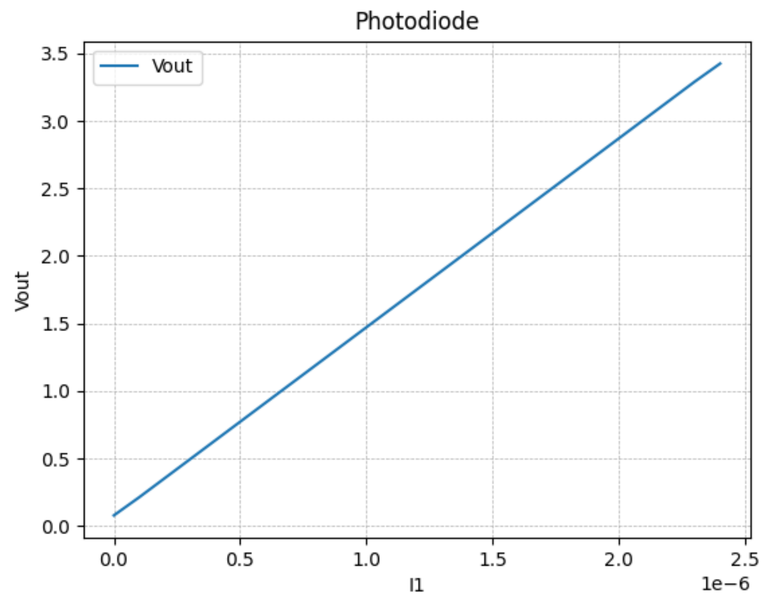
3.1 Photodiode

3.1.1 Code snippet

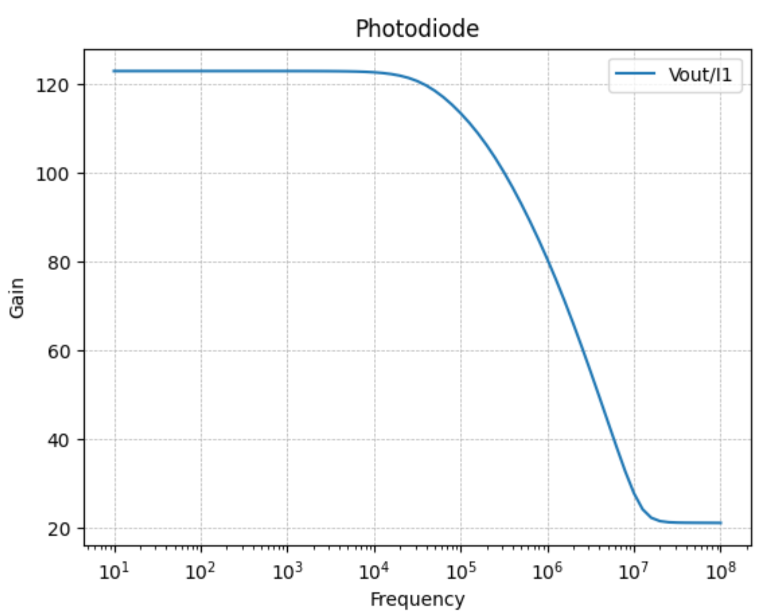
```
Photodiode
*Including the predefined subcircuit files
.include lm324.txt
I1 1 0 0
CJ 1 0 11p
x1 2 1 4 5 out lm324
R1 1 out 1.4Meg
C1 1 out 3.3p
R2 2 4 13.7k
R3 2 0 280
C2 2 0 1u
Vref 2 0 dc 0.1
VCC 4 0 dc 5
VEE 5 0 dc 0
.dc I1 0 2.4u 0.1u
.control
run
plot v(out)
.endc
.end
```

3.1.2 Simulation results

Given below is the plot for V_{out} vs I_1 obtained by performing DC analysis on I_1:



Given below is the plot for the gain, V_{out}/I_1, obtained by AC analysis of the analysis of the circuit by biasing I_1 at $1.5\mu A$:



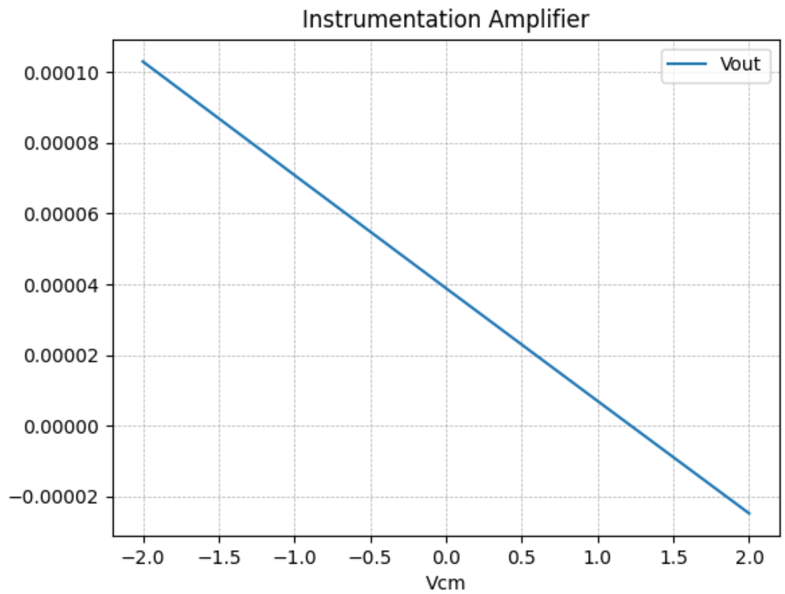
3.2 Instrumentation Amplifier

3.2.1 Code snippet

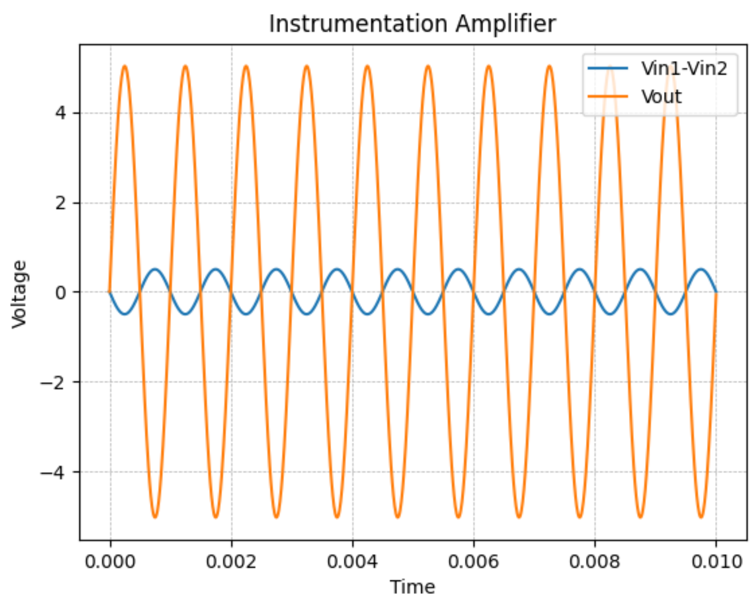
```
Instrumentation Amplifier
*Including the predefined subcircuit files
.include uA741.txt
Vcm cm 0 dc 0
Vi1 cm in1 sin(0 250m 1k 0 0)
Vi2 in2 cm sin(0 250m 1k 0 0)
x1 in1 1 9 10 3 uA741
x2 in2 2 9 10 4 uA741
x3 6 5 9 10 out uA741
R1 3 5 10k
R2 5 out 10k
R3 4 6 10k
R4 6 8 10k
R5 4 2 10k
R6 3 1 10k
R10 1 2 2.21k
Vref 8 0 dc 0
VCC 9 0 dc 15
VEE 10 0 dc -15
.tran 0.01m 10m
.control
run
plot v(in1,in2) v(out)
.endc
.end
```

3.2.2 Simulation results

Given below is the plot for V_{out} vs V_{cm} obtained by performing DC analysis on V_{cm}:



Given below is the plot for $V_{i_1} - V_{i_2}$ and V_{out} waveforms obtained from the transient analysis of the circuit:



4 Experimental results

4.1 Photodiode

The 3dB cut-off frequency of the given circuit is $3.8 \times 10^4 Hz$ which is also the bandwidth as it is a low-pass filter.

4.2 Instrumentation Amplifier

The output of the amplifier U_2 is $(1 + 2R_5/R_{10}) \times V_{i_2}$. Similiarly, the output of U_3 is $(1 + 2R_6/R_{10}) \times V_{i_1}$. U_1 acts as a differential amplifier and outputs:

$$V_{out} = (1 + (\frac{2R_5}{R_{10}})(\frac{R_4}{R_3}) \times (V_{i_2} - V_{i_1}) \tag{1}$$

Putting in the resister values, we get the gain as **10**.