CE 3111.103

Lab 7: Operational Amplifiers

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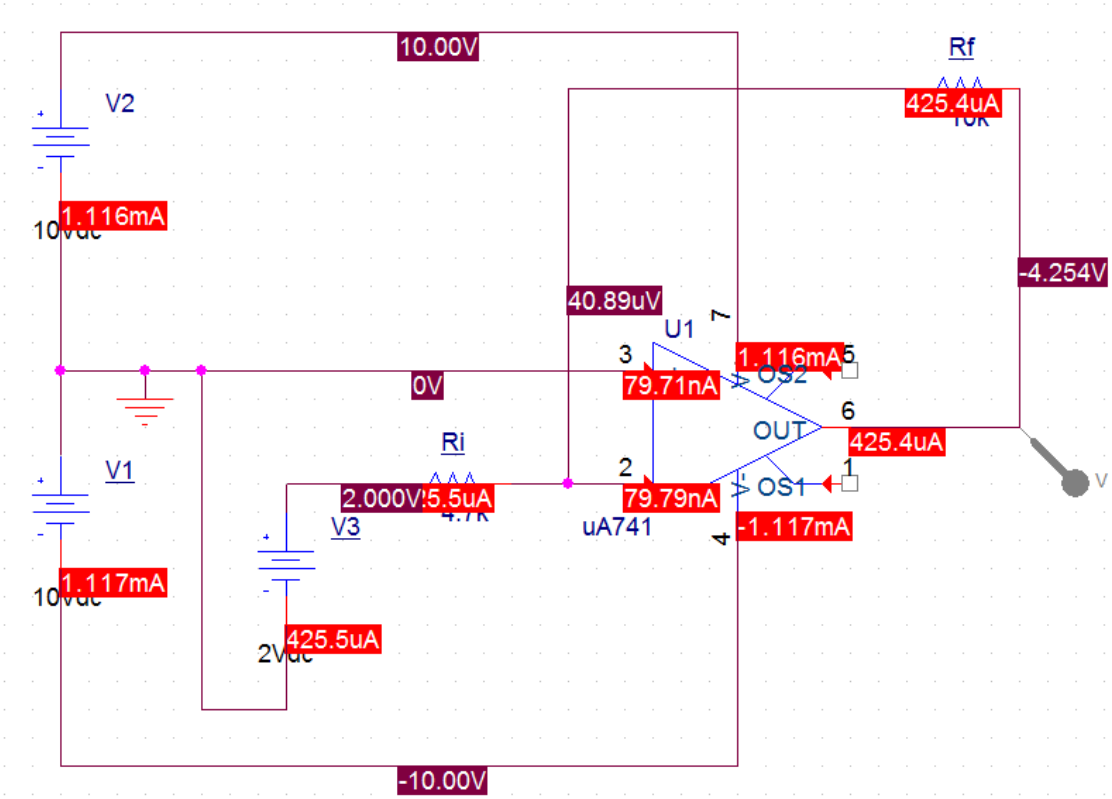
Objective

Study operational amplifiers and their applications. Simulate and building some basic operational amplifier circuits.

Experimental Results

- Inverting amplifier
    1. PSpice circuit



    2. comparison:

V3 in	Vout theoretical	Vout (end of R to GND)
2	-4.254	-4.243
2.05	-4.361	-4.3496
2.08	-4.425	-4.44135
2.1	-4.467	-4.44552

Measuring device and the quality of amplifier affect the measured value.

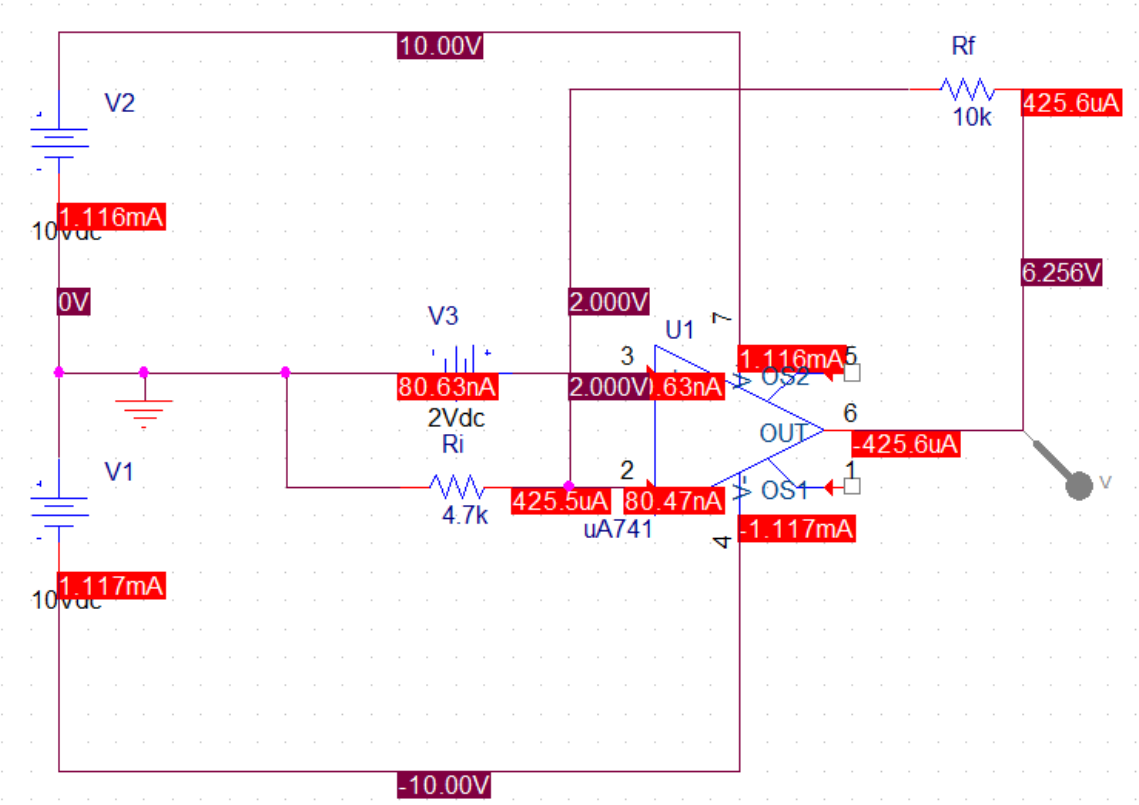
    3. $V_3 = V_{out}(-\frac{R_i}{R_f})$

4. Table

V3 in	Theoretical Close loop gain	Actual close loop gain	Calculated gain
2	-2.127	-2.1215	$\frac{-R_f}{R_i} = -2.12$
2.05	-2.127317073	-2.121756098	
2.08	-2.127403846	-2.135264423	
2.1	-2.127142857	-2.116914286	

Small discrepancies occur due to the quality and the operational environment of the op amp.

- Non-Inverting amplifier
  1. PSpice circuit



2. Comparison

V3 in	Vout theoretical	Vout
2	6.256	6.26252
2.05	6.412	6.4213
2.08	6.506	6.515
2.1	6.569	6.577

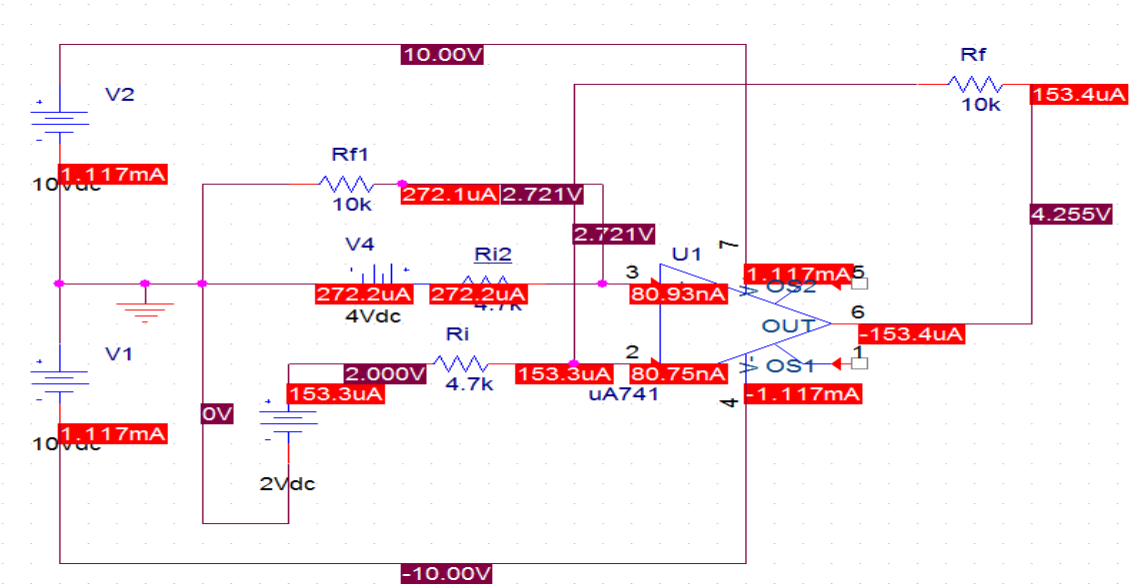
Measuring device and the quality of amplifier affect the measured value.

3. $V_3 = \frac{V_{out}}{1+\frac{R_f}{R_i}}$
4. Table

V3 in	Theoretical Close loop gain	Actual close loop gain	Calculated gain
2	3.128	3.13126	$1+\frac{R_f}{R_i} = 3.12765$
2.05	3.127804878	3.132341463	
2.08	3.127884615	3.132211538	
2.1	3.128095238	3.131904762	

Small discrepancies occur due to the quality and the operational environment of the op amp.

- Differencing amplifier
  1. PSpice



  2. Comparison

V3 in	V4 in	Vout theoretical	Vout
2	4	4.255	4.2513
2.05	4	4.149	4.1448
2.08	4	4.085	4.081
2.1	4	4.042	4.0386
2	4.05	4.361	4.3547
2	4.08	4.425	4.4183
2	4.1	4.468	4.4609

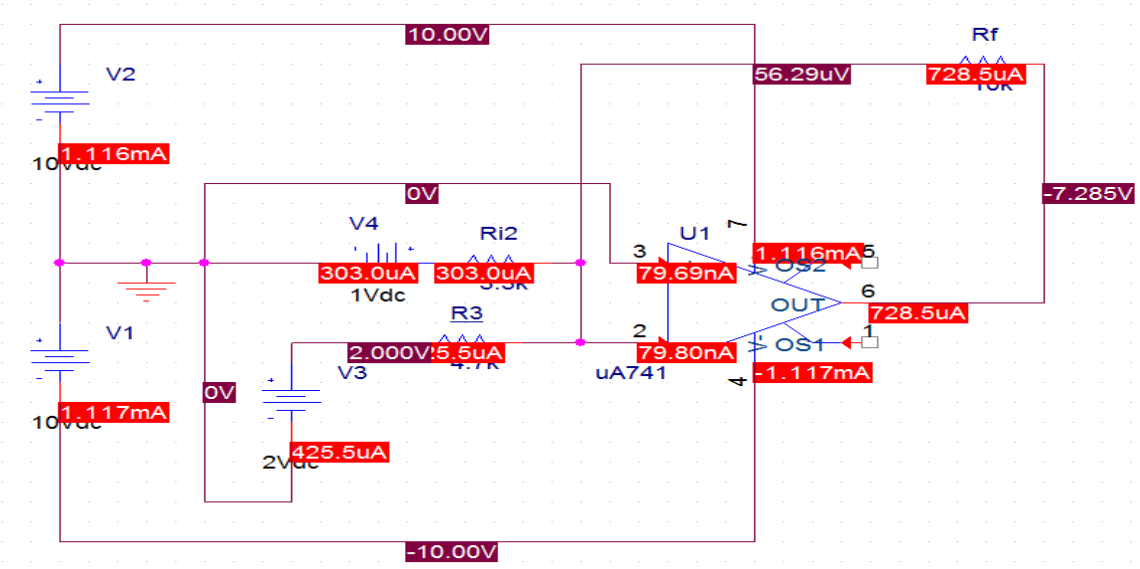
Measuring device and the quality of amplifier affect the measured value.

3. $V_3 = V_4 - V_{out}\frac{R_i}{R_f}$; $V_4 = V_{out}\frac{R_i}{R_f} + V_3$
4. Table

V3 in	V4 in	Theoretical Close loop gain	Actual close loop gain	Calculated gain
2	4	2.1275	2.12565	$\frac{R_f}{R_i}$=2.12
2.05	4	2.127692308	2.125538462	
2.08	4	2.127604167	2.125520833	
2.1	4	2.127368421	2.125578947	
2	4.05	2.127317073	2.124243902	
2	4.08	2.127403846	2.124182692	
2	4.1	2.127619048	2.124238095	

Small discrepancies occur due to the quality and the operational environment of the op amp.

- Summing Amplifier
  1. PSpice



  2. Comparison

V3 in	V4 in	Vout theoretical	Vout
2	1	-7.285	-7.2572
2.05	1	-7.391	-7.3629
2.08	1	-7.455	-7.4264
2.1	1	-7.497	-7.4686
2	1.05	-7.436	-7.4045
2	1.08	-7.527	-7.4948
2	1.1	-7.588	-7.5551

Measuring device and the quality of amplifier affect the measured value.

3. $V_3 = \frac{V_{out} - V_4\frac{R_f}{R_4}}{\frac{R_f}{R_3}}; V_4 = \frac{V_{out} - V_3\frac{R_f}{R_3}}{\frac{R_f}{R_4}}$
4. Table

V3 in	V4 in	Theoretical Close loop gain(V3)	Actual close loop gain(V3)	Theoretical Close loop gain(V4)	Actual close loop gain(V4)	Calculated gain (V3)	Calculated gain (V4)
2	1	-3.6425	-3.6286	-7.285	-7.2572		
2.05	1	-3.605365854	-3.591658537	-7.391	-7.3629		
2.08	1	-3.584134615	-3.570384615	-7.455	-7.4264		
2.1	1	-3.57	-3.55647619	-7.497	-7.4686	-5.15765	-9.41265
2	1.05	-3.718	-3.70225	-7.081904762	-7.051904762		
2	1.08	-3.7635	-3.7474	-6.969444444	-6.93962963		
2	1.1	-3.794	-3.77755	-6.898181818	-6.868272727		

Discrepancies occur due slightly degraded amplifier used in the lab.

Analysis

1.

Figure	Resistance seen by V_3
7-2	$\frac{41.97\mu V}{79.79nA} = 526\Omega$
7-3	$\frac{2.1V}{80.51nA} = 26083716\Omega$
7-4	$\frac{2.789V}{80.77nA} = 34530147\Omega$
7-5	$\frac{57.84\mu V}{79.81nA} = 724.721\Omega$

2. $V_{out} = -V_3\frac{R_f}{R_i} + V_4(\frac{R_1}{R_2+R_1})(\frac{R_i+R_f}{R_i})$
3.

Figure	Gain seen by V_3
7-2	$-\frac{1}{\frac{1}{A} + \frac{R_i}{R_f}(\frac{1}{A}+1)}$
7-3	$\frac{A}{1 + \frac{R_i}{R_i + R_f}A}$
7-4	$\frac{R_f}{R_i} + A(\frac{R_1}{R_2+R_1})(\frac{R_i+R_f}{R_i})$
7-5	$-(\frac{V_3}{R_4} + \frac{V_4}{R_3})[R_f \| A(R_3 \| R_4 \| R_f)]$

4. Open loop gain can be determined in inverting and non-inverting amplifiers only. Since it depends on analogue frequency, sometime is not reliable to conclude open loop gain.

Figure	Open loop gain
7-2 inverting	$\frac{V_{out}}{V_3 - \frac{V_3 R_i}{R_i + R_f}}$
7-3 non-inverting	$\frac{V_{out}}{V_3 - \frac{V_{out}}{R_f(R_f \| \| R_i)}}$

Conclusion

Overall, the results closely match the theoretical assumption. Discrepancies found are due to bad quality of the circuit.