Electronics Lab 5: Amplifiers

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The purpose of this lab was to understand in practice how op amps worked by creating inverting and non-inverting amplifiers.

I. INTRODUCTION

The purpose of this lab was to understand how op amps work in practice by creating inverting and non-inverting amplifiers, with gains of -20 and 10 respectively.

II. THEORETICAL MODEL

For the non-inverting amplifier, we have the following model.

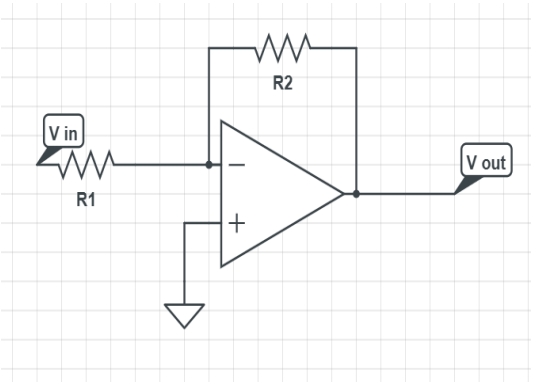

FIG. 1. Inverting Amplifer

This gives us an expected gain of $V_{\text{out}} = -\frac{R_2}{R_1}V_{\text{in}}$, since the current is $-\frac{V_in}{R_1}$, which is then multiplied by R_2. For the non-inverting case, we have:

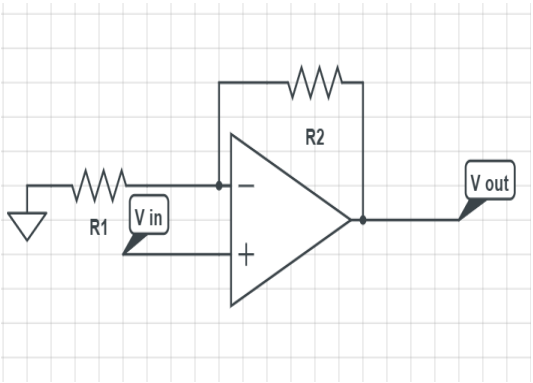

FIG. 2. Non-inverting amplifer

For the non-inverting scenario, the current is set via the non-inverting input, and it becomes $\frac{V_{\text{in}}}{R_1}$, and the final V_{out} is given by $V_{\text{in}} + \frac{R_2}{R_1}V_{\text{in}}$, with a gain of $1 + \frac{R_2}{R_1}$.

III. EXPERIMENT

For the experiment, it was pretty straightforward. 2 Resistors and a JRC4558 dual op-amp were used. The pinout of the op-amp are included below:

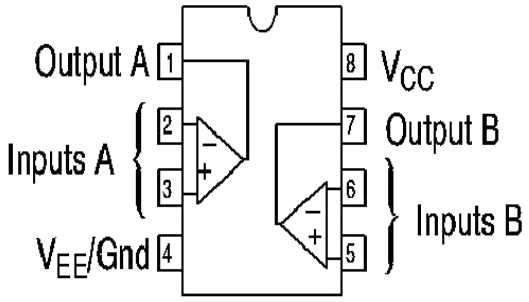

FIG. 3. Dual Op-Amp pinout

A. Data

For the inverting op amp, there was a gain of -22, with resistor values of $R_2 = 20\text{k}\Omega$ and $R_1 = 1\text{k}\Omega$ and for the non-inverting circuit, there was a gain of 10 with resistor values of $R_1 = 1\text{k}\Omega$, and $R_2 = 9\text{k}\Omega$. The input and outpus voltages for the respective circuits are included below.

Freq	Vin	Vout	Dphi (uS)	LogFreq	Gain	LogGain
400	0.34	-7.6	1.32	2.602	22.353	26.987
630	0.34	-7.6	860	2.799	22.353	26.987
986	0.34	-7.8	500	2.994	22.941	27.212
1500	0.38	-8.4	360	3.176	22.105	26.890
3120	0.38	-8.4	160	3.494	22.105	26.890
4120	0.38	-8.4	124	3.615	22.105	26.890
6330	0.38	-8.4	88	3.801	22.105	26.890
7692	0.38	-8.4	62	3.886	22.105	26.890
9615	0.38	-8.4	54	3.983	22.105	26.890
12820	0.38	-8.4	36	4.108	22.105	26.890
23800	0.38	-8.4	22	4.377	22.105	26.890
31750	0.38	-8.4	16.4	4.502	22.105	26.890
40000	0.38	-8.4	12.6	4.602	22.105	26.890
72000	0.38	-8	6.8	4.857	21.053	26.466
94000	0.38	-7.6	6	4.973	20.000	26.021
122000	0.42	-6.8	5	5.086	16.190	24.185
137000	0.42	-6	2.7	5.137	14.286	23.098
167000	0.42	-5.2	1.8	5.223	12.381	21.855
193000	0.42	-4.8	1.7	5.286	11.429	21.160
270000	0.42	-3.6	0.84	5.431	8.571	18.661
538000	0.42	-2.8	0.4	5.731	6.667	16.478

Freq	Vin	Vout	Dphi	LogFreq	Gain	LogGain
200	0.42	4.2	0	2.301	10.000	20.000
740	0.4	4	0	2.869	10.000	20.000
1074	0.4	4	0	3.031	10.000	20.000
3090	0.42	4.2	0	3.490	10.000	20.000
5100	0.42	4.2	0	3.708	10.000	20.000
7200	0.42	4.2	0	3.857	10.000	20.000
12200	0.42	4.2	0	4.086	10.000	20.000
23650	0.42	4.2	0	4.374	10.000	20.000
63000	0.42	4.2	0.4	4.799	10.000	20.000
112000	0.42	4.2	0.4	5.049	10.000	20.000
295000	0.42	3	0.44	5.470	7.143	17.077
430000	0.42	2.12	0.44	5.633	5.048	14.062
480000	0.42	1.92	0.36	5.681	4.571	13.201
685000	0.42	1.32	0.36	5.836	3.143	9.946
810000	0.42	1.08	.36	5.908	2.571	8.203
950000	0.42	0.95	0.36	5.978	2.262	7.089
1244000	0.42	0.72	0.3	6.095	1.714	4.682
1770000	0.42	0.52	0.24	6.248	1.238	1.855
1634000	0.42	0.6	0.2	6.213	1.429	3.098
2250000	0.42	0.42	0.1	6.352	1.000	0.000

FIG. 4. Gains for Inverting (Left) and Non-inverting (Right)

The slew rate becomes quite obvious in the below picture:

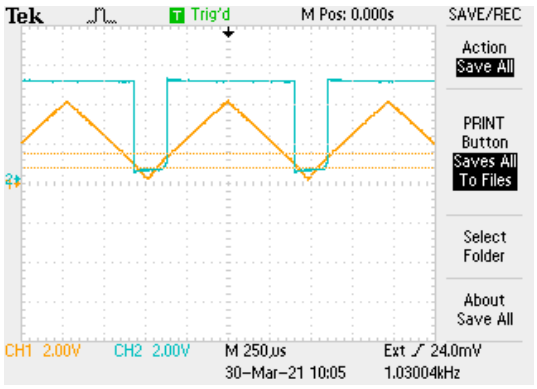

FIG. 5. Caption

The bode plots for each respective amplifer are included below:

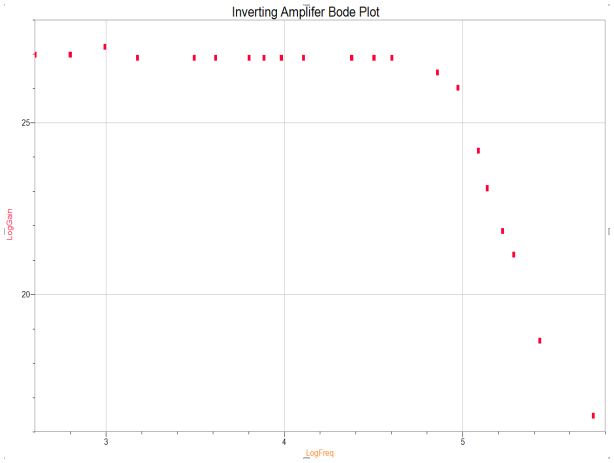

FIG. 6. Inverting Amplifier Bode Plot

The non-inverting

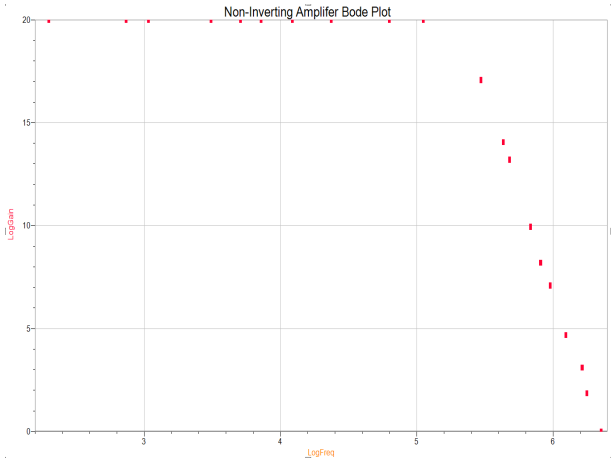

FIG. 7. Non-Inverting Amplifier Bode Plot

IV. CONCLUSION

The slew rate was found to be 1.7 V/μs, which was consistent with the specs for the JRC4558 dual op-amp. Clipping occured when the output exceeded 16V, which makes sense as this was the rail of the power supply for the op-amp. Unity gain was found at 1.665 MHz. Given the resistor values, the circuits closely followed the expected outputs for low frequencies with no slew rate distortion. However, once the frequencies began to increase, slew rate distortion became a problem and the gains deviated from the model. The phase for the inverting amplifer was always non-zero as the inverting amplifer would be out of phase with the original input (hence inverting) and the non-inverting was near zero, as it was just a direct increase to the amplitudes.

ACKNOWLEDGEMENTS

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