

Study of Operational Amplifiers (OPAMP)

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1 Aim

In this experiment we will study OPAMPs (Operational Amplifiers), mainly their application in circuits as inverting and non-inverting amplifiers. We will also, see their application as voltage adders, and subtractors.

2 Theory

Opamps have a very high gain, and they work on the principle of virtual ground. Below is the symbol for an Opamp.

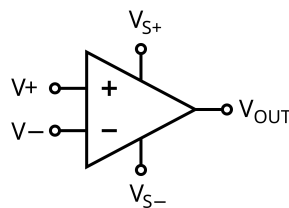


Figure 1: An operational amplifier (Souce: The Internet)

As we can see in the given figure above, an opamp has an inverting input, and a non-inverting input. The gain of the amplifier is given by

$$A = \frac{V_{out}}{V_+ - V_-}$$

Generally A is extremely large, however an OPAMP cannot produce arbitrarily high voltages. The maximum voltage it can produce is decided the power supply connected to it, which is denoted by $V_{S\pm}$. In this experiment and in most cases in general, we have chosen $V_S = 15V$. So, the output of the OPAMP saturates at V_S , and hence, it does not follow the linear gain relation we have mentioned above.

Also, our opAmp of choice in this experiment is the LM741 Operational amplifier. The pinouts of this IC have been given below.

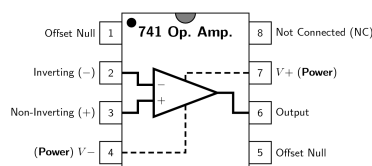


Figure 2: LM741 pinouts (Souce: The Internet)

2.1 Inverting Amplifier

In this configuration, the output of the OPAMP is of the opposite sign of the input voltage. The circuit diagram of this configuration is given below.

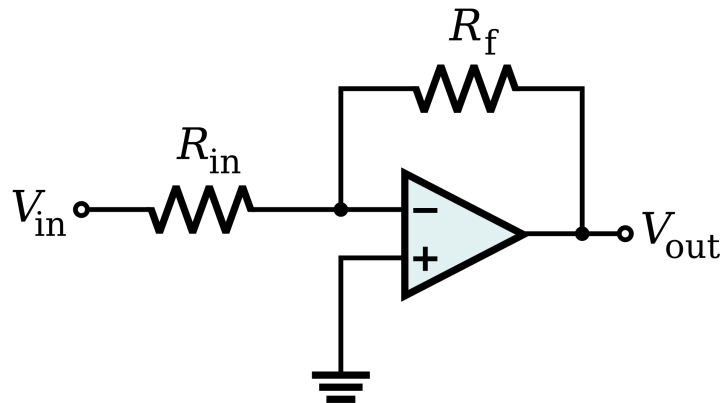


Figure 3: An op amp connected in the inverting amplifier configuration (Source: Internet)

In this case, the gain of the amplifier is decided by the two resistors, and is given by the formula

$$A = -\frac{R_f}{R_i}$$

The minus sign here is where the "inverting" nature arises, since the input is connected to the inverting input terminal of the OPAMP.

2.2 Non Inverting Amplifier

In this configuration, the output of the OPAMP is of the same sign of the input voltage. The circuit diagram of this configuration is given below.

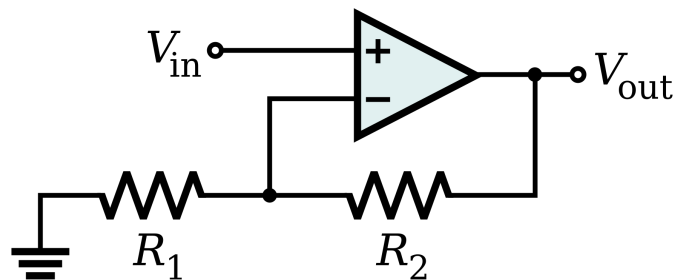


Figure 4: An op amp connected in the non-inverting amplifier configuration (Source: Internet)

In this case, the gain of the amplifier is decided by the two resistors, and is given by the formula

$$A = 1 + \frac{R_2}{R_1}$$

Again, it's non-inverting because this time, the input signal is being fed into the non-inverting terminal of the OPAMP.

2.3 Voltage Adder

In this configuration, the output of the OPAMP is given by a weighted sum of the input voltages, with a minus sign, because it's being sent through the inverting terminal of the OPAMP. The circuit diagram for this configuration is given below.

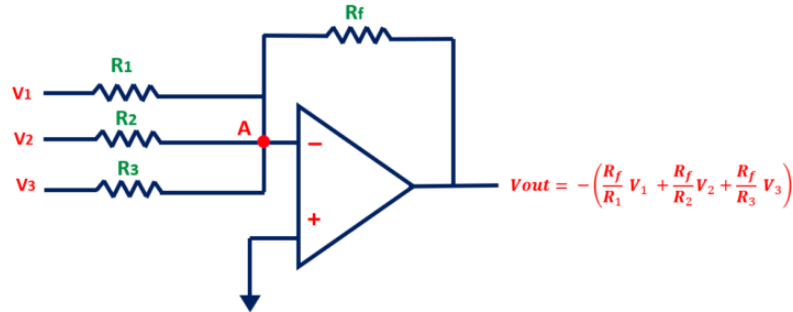


Figure 5: An op amp connected in the voltage adder configuration (Source: Internet)

In this configuration, the output of the OPAMP is given by,

$$V_o = -R_f \left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3} \right)$$

2.4 Voltage Subtractor

In this configuration, the output of the OPAMP is given by a weighted difference of the input voltages, with a minus sign, because it's being sent through the inverting terminal of the OPAMP. The circuit diagram for this configuration is given below.

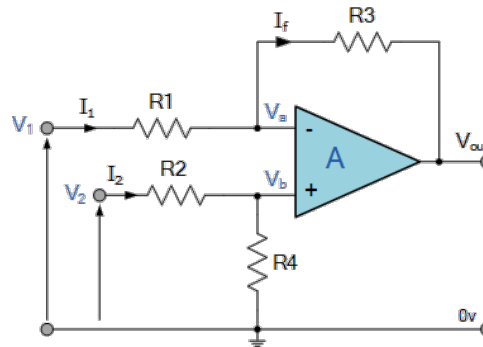


Figure 6: An op amp connected in the voltage subtractor configuration (Source: Internet)

In this configuration, the output of the OPAMP is given by,

$$V_o = -R_f \left(\frac{V_1}{R_1} - \frac{V_2}{R_2} \right)$$

3 Data and Analysis

The data tables for this experiment have been provided in the supplementary section.

3.1 Analysis

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4 Conclusion

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5 Sources Of Error

1. Chicken Dak Bungalow

6 Supplementary

$-R_f/R_i$	A(Theo.)	$V_i(V)$	$V_o(V)$	A(Expt)
-9.8/1	-9.8	-0.5	4.9	-9.8
-9.8/1	-9.8	-0.99	9.67	-9.767676768
-9.8/1	-9.8	0.5	-4.91	-9.82
-9.8/1	-9.8	1	-9.78	-9.78
-9.8/2.16	-4.537037037	1	-4.56	-4.56
-9.8/2.16	-4.537037037	0.5	-2.28	-4.56
-9.8/2.16	-4.537037037	-0.99	4.49	-4.535353535
-9.8/2.16	-4.537037037	-0.5	2.27	-4.54
-21.7/9.8	-2.214285714	-0.49	1.09	-2.224489796
-21.7/9.8	-2.214285714	-1	2.2	-2.2
-21.7/9.8	-2.214285714	0.49	-1.09	-2.224489796
-21.7/9.8	-2.214285714	1	-2.2	-2.2
-2.16/1	-2.16	1	-2.16	-2.16
-2.16/1	-2.16	0.5	-1.08	-2.16
-2.16/1	-2.16	-1	2.17	-2.17
-2.16/1	-2.16	-0.5	1.08	-2.16
-3.16/1	-3.16	-1	3.17	-3.17
-3.16/1	-3.16	0.51	-1.62	-3.176470588
-3.16/1	-3.16	1	-3.17	-3.17
-3.16/1	-3.16	-0.49	1.56	-3.183673469

Table 1: Inverting Amplifier

$1 + R_f/R_i$	A(Theo.)	Vi(V)	Vo(V)	A(Expt)
1+2.16/1	3.16	1	3.17	3.17
1+2.16/1	3.16	0.5	1.58	3.16
1+2.16/1	3.16	-1	-3.15	3.15
1+2.16/1	3.16	-0.5	-1.57	3.14
1+9.08/1	10.08	-0.49	-5.36	10.93877551
1+9.08/1	10.08	-1	-10.82	10.82
1+9.08/1	10.08	0.5	5.46	10.92
1+9.08/1	10.08	1	10.9	10.9
1+21.7/9.8	3.214285714	1	3.2	3.2
1+21.7/9.8	3.214285714	0.5	1.61	3.22
1+21.7/9.8	3.214285714	-1	-3.19	3.19
1+21.7/9.8	3.214285714	-0.5	-1.6	3.2
1+9.8/2.16	5.537037037	-0.5	-2.75	5.5
1+9.8/2.16	5.537037037	-0.99	-5.48	5.535353535
1+9.8/2.16	5.537037037	0.5	2.77	5.54
1+9.8/2.16	5.537037037	1	5.53	5.53
1+3.16	4.16	0.99	4.2	4.242424242
1+3.16	4.16	0.5	2.11	4.22
1+3.16	4.16	-0.99	-4.16	4.202020202
1+3.16	4.16	-0.49	-2.04	4.163265306

Table 2: Non-Inverting Amplifier

SL no.	V1(V)	V2(V)	V3(V)	Column 1	Vo(meas)	Vo(Theo)
1	4.93	2.01	1.07	8.16	-8.16	8.01
2	5.91	2.42	1.28	9.8	-9.8	9.61
3	2.4	1.18	0.56	4.2	-4.2	4.14
4	3.94	1.58	0.86	6.5	-6.5	6.38
5	4	1.83	1.16	7.13	-7.13	6.99
6	3.28	1.45	0.8	5.63	-5.63	5.53
7	3.34	1.64	0.77	5.86	-5.86	5.75
8	5.12	2.57	1.06	8.93	-8.93	8.75
9	4.49	2.2	1.04	7.88	-7.88	7.73
10	5.7	2.13	0.89	8.92	-8.92	8.72

Table 3: Voltage Adder

SL. no.	V1(V)	V2(V)	Vo(Meas)	Vo(Theo)
1	0.15	1.04	0.91	0.89
2	0.26	1.04	0.82	0.78
3	0.39	1.04	0.64	0.65
4	1.12	3	1.97	1.88
5	1.39	3.11	1.81	1.72
6	1.59	4.07	2.6	2.48
7	0.86	3.55	2.78	2.69
8	3.02	5.98	3.15	2.96
9	1.41	5.8	4.54	4.39
10	1.08	4.42	3.46	3.34
11	5.31	6.2	1.14	0.89
12	3.69	4.56	1.05	0.87
13	3.34	4.46	1.29	1.12
14	4.13	3.25	-0.71	-0.88
15	4.85	3.81	-0.83	-1.04
16	5.79	4.73	-0.82	-1.06
17	3.36	1.6	-1.64	-1.76
18	3.5	2.25	-1.11	-1.25
19	5.32	1.15	-4.01	-4.17
20	5.13	1.11	-3.87	-4.02
21	3.05	0.66	-2.3	-2.39
22	2.19	0.47	-1.65	-1.72
23	1.43	0.3	-1.07	-1.13

Table 4: Voltage Subtractor