Macau University of Science and Technology
CE102
Analog Circuit

Proportional, Summing Operational Circuits Report

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Objective

To learn how to construct different proportional, summing circuits using a op-amp.

To learn the methods to test and analyze those circuits

Device Required

Digital Multi-Meter (DMM)

Resistors

Operational Amplifier LM741

SS1798 DC Supply

Breadboard

Prelab Questions

Analyze the five circuits which are shown below, find the transfer functions of each circuit.

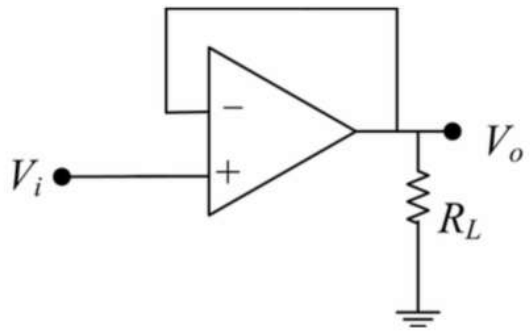
Calculate all the theoretical values in Table 4.2,4.3,4.4,4.5

Voltage Follower

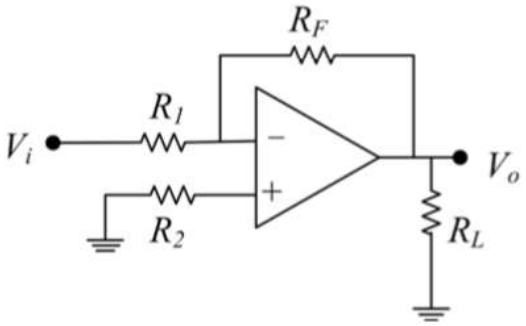
the circuit has negtive feedback, so it has virtual short, meanwhile, has virtual open

V_i=V_0

A_v=$\frac{V_0}{V_i}$=1



Inverting Proportional Amplifier



$\frac{V_i-0}{R_1}=\frac{0-V_0}{R_F}$

$V_0=-\frac{R_F}{R_1}V_i=-10V_i$

$A_v=\frac{V_0}{V_i}=-\frac{R_F}{R_1}$

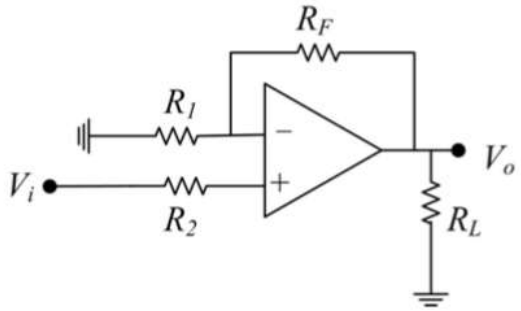
Non-inverting Proportional Amplifier

$\frac{0-V_i}{R_1}=\frac{V_i-V_0}{R_F}$

$V_i(R_1+R_F)=V_0R_1$

$V_0=\frac{R_1+R_F}{R_1}V_i=11V_i$

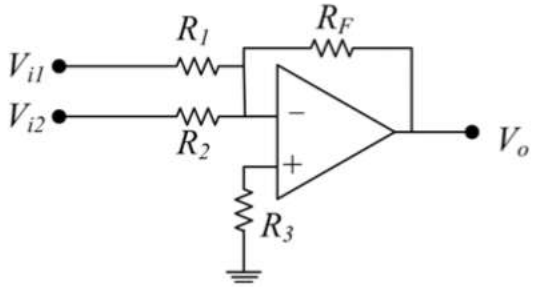
$A_v = \frac{V_0}{V_i} = \frac{R_1 + R_F}{R_1}$



Inverting Summing Amplifier

$\frac{V_{i1} - 0}{R_1} + \frac{V_{i2} - 0}{R_2} = \frac{-V_0}{R_F}$

$V_0 = -\frac{(V_{i1} R_2 + V_{i2} R_1) R_F}{R_1 R_2}$

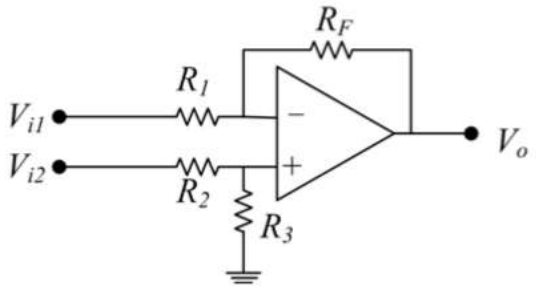


Double-Input Summing Amplifier

$V_0 = \left(1 + \frac{R_F}{R_1}\right) \left(\frac{\frac{R_3}{R_2}}{1 + \frac{R_3}{R_2}}\right) v_{I2} - \left(\frac{R_F}{R_1}\right) v_{I1}$

$\frac{R_3}{R_2}=\frac{R_F}{R_1}$

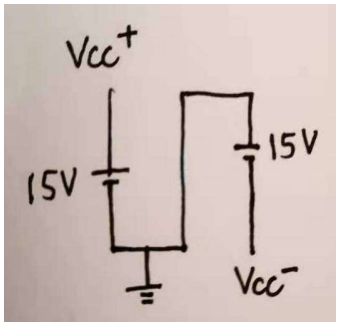
$V_0=\frac{R_F}{R_1}(V_{I2}\text{-}V_{I1})$



Procedures

Circuit Set up

Without applying the DC power, we connect the circuit on the breadboard. Carefully check all connection to make sure there is no short-circuit in whole circuit. As much as possible, make sure that the devices are not too tightly connected, and as much as posible let LM741 performed at the middle position on breadboard. Pay attention to connect Vcc power correctly.



Voltage Follower

1. Connect the Voltage follower circuit, connect the power supplies V_{cc-} =-15V and V_{cc+} = +15V to LM741.

2. Set R_L =∞. Adjust input voltage V_i, measure input and output voltages using the DMM and fill Table 4.1.

V_i(V)	-2	-0.5	0	0.5	1
Actual V_i	-1.996	-0.4952	0.00165	0.4956	0.992
V_o (V)	-1.996	-0.496	-0.0012	0.4923	0.9889
Theory V_o	-2	-0.5	0	0.5	1

the theory caiculation has been done on table,

V_i=V_0

Inverting Proportional Amplifier

1. Connect the circuit, Set R_1 =R_2=10kΩ, R_F=100kΩ, R_L=∞. Adjust the input voltage V_i and fill Table 4.2

the experimental record data are in below.

the theory caiculation has been done on prelab questions,

V_0=-$\frac{R_F}{R_1}V_i$=-10V_i

Theory Vi (v)	0.03	0.1	0.3	1	3
Actual Vi (v)	0.0316	0.099	0.296	0.9917	2.995
Theory Vo (v)	-0.3	-1	-3	-10	-30
Actual Vo (v)	-0.339	-1.0579	-3.094	-9.40	-14.385
Error	11.5%	5.47%	3.04%	6.38%	108.55%

Also noticed, when V_i=3V, theory V_0 is -30V, however, actual data reaches -14V nearly, the reason is that we set Vcc range is 15V so the actual data has already reached the saturate state.

We also calculate the relative error by subtracting the theoretical value from the measured value and dividing by the theoretical value.

Non-inverting Proportional Amplifier

1. Connect the circuit, Set R_1 =R_2=10kΩ, R_F=100kΩ, R_L=∞. Adjust the input voltage V_i and fill Table 4.3

the experimental record data are in below.

Theory Vi (v)	0.03	0.1	0.3	1
Actual Vi (v)	0.03024	0.09939	0.2959	0.9910
Theory Vo (v)	0.33	1.1	3.3	11
Actual Vo (v)	0.3012	1.1042	3.33	11.264
Error Vo (%)	9.56%	0.38%	0.9%	2.34%

the theory calculation is V_0=$\frac{R_1+R_F}{R_1}V_i$=11V_i

Inverting Summing Amplifier

1. Connect the circuit, Set R_1 =R_2=10kΩ, R_3=R_F=100kΩ, R_L=∞. Adjust the input voltage V_i and fill Table 4.4

the experimental record data are in below.

the theory calculation is V_0=-$\frac{(V_{i1}R_2+V_{i2}R_1)R_F}{R_1R_2}$

V_{i2} (V)	0.3	-0.3
V_{i1} (V)	0.2	-0.2
Actual V_{i2} (V)	0.294	-0.294
Actual V_{i1} (V)	0.195	-0.196
Theory V_o	-5	5
Actual V_o	-5.184	5.11

Double-Input Summing Amplifier

1. Connect the circuit, Set R_1 =R_2=10kΩ, R_3=R_F=100kΩ, R_L=∞. Adjust the input voltage V_i and fill Table 4.5

the experimental record data are in below.

the theory calculation is V_0=$\frac{R_F}{R_1}$(V_{I2}-V_{I1})

V_{i2}(V)	1	2	0.2
V_{i1}(V)	0.5	1.8	-0.2
Actual V_{i2}	1.001	1.779	0.19
Actual V_{i1}	0.497	1.97	-0.196
Theory V_o	5	2	4
Actual V_o	5.175	2.123	4.125

Error Analysis

With respect to sources of error, real op amps cannot be ideal, for example, there is a bias current, so it is not completely virtual open, there is an offset voltage, so it is not completely virtual short, there may also be an input impedance that is not infinite and an op amp gain that is not infinite, and so on.

problems during experiment

After this experiment, we mainly started by building 5 different circuits, which further reinforced what we had learned in class, but also revealed that there were still some detail problem in our experimentation process. When we record the data, we must not forget to write down the units of the data clearly to avoid making mistakes when writing the lab report. At first we miss the voltage unit " mV " when we record the data.

summary

During the experiment, we built five different circuits on a breadboard. the volatge follower circuit do not need resistor, so it is the The Simplest Experiment, we just constuct them with wires and measured. the later four experiments need resistors we used the DMM to measure the actual input and output voltages, but also found that there were some deviations between the theoretical values and the measured actual values. After the comparison, we concluded that there may be incomplete virtual short and incomplete virtual open, which may lead to the experimental error, and also summarized some of our own shortcomings in the experiment, such as the missing units when recording the experimental data.