EEEN 202 ELECTRICAL AND ELECTRONIC CIRCUITS II

EXPERIMENT 2: ANALYZING OPERATIONAL AMPLIFIERS OPERATING AS SUMMING AMPLIFIER AND DIFFERENTIAL AMPLIFIER

SUMMING AMPLIFIER

The use of operational amplifier as a summing amplifier is shown in Figure 2.1. The summing circuit multiplies each of the input voltages by the gain of the circuit. Then the results are summed and transferred to the output. The number of inputs of the summing amplifier can be increased. The important thing is that, the multiplication of the summation of the inputs with the gain of the circuit must be smaller than the supply voltage. Otherwise, the output voltage becomes 1V less than the supply voltage.

The summing amplifier operates as an inverting amplifier. As we know, there is a phase difference with a degree of 180 between the input and the output signals of the inverting amplifiers.

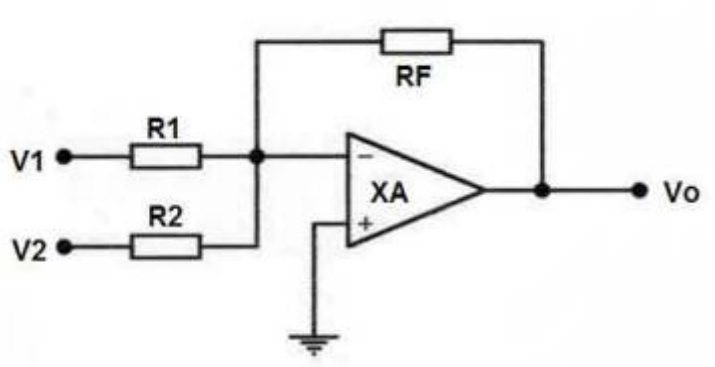


Figure 2.1

The output voltage is;

$$V0 = -\left(\frac{RF}{R1}V1 + \frac{RF}{R2}V2\right)$$

For example, if we choose the resistances as $RF = R1 = R2$;

$$V0 = -(V1 + V2)$$

DIFFERENTIAL AMPLIFIER

The operation of the operational amplifier as a differential amplifier is given in Figure 2.2. As it is seen, the circuit operates as inverting and

noninverting amplifier at the same time. Since these operations are inverse of each other, the difference of the inputs is amplified at the output.

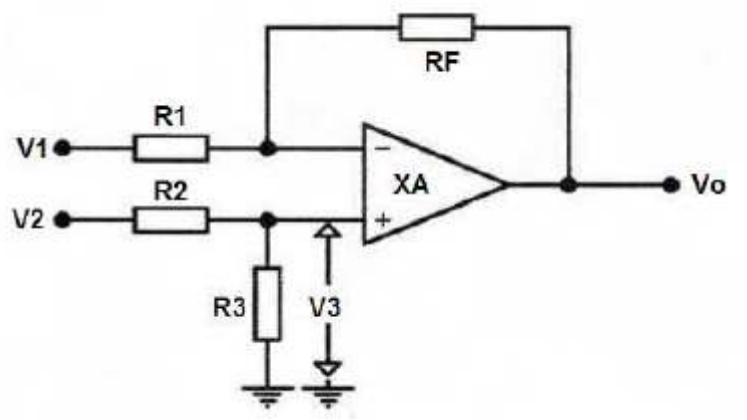


Figure 2.2

Let's calculate the voltage, V3, at the non-inverting input. V2 is the input voltage. Then the current passing through the resistances R2 and R3 is;

$$\mathrm{I} = \frac{V2}{R2 + R3}$$

$$V3 = \mathrm{I} \cdot R3$$

If we place the current equation;

$$\mathrm{I} = \frac{V2}{R2 + R3} \cdot R3 = \frac{V2 \cdot R3}{R2 + R3}$$

The output voltage (**V0**) is the difference of the voltages generated by the inputs separately.

If we call the output generated by the voltage at the inverting input (**V1**), **V01**; then,

$$V01 = -(V1 \cdot A) = -\left(\frac{V1 \cdot RF}{R1}\right)$$

If we call the output generated by the voltage at the non-inverting input (**V2**), **V02**; then

$$V02 = -(V3 \cdot A) = -\left(\frac{V2 \cdot R3}{R2 + R3}\right) \cdot \left(1 + \frac{RF}{R2}\right)$$

The output voltage is the difference of the voltages V01 and V02.

$$V0 = \left(\frac{V2 \cdot R3}{R2 + R3}\right) \cdot \left(1 + \frac{RF}{R2}\right) - \left(\frac{V1 \cdot RF}{R1}\right)$$

If we choose the resistances as R1=R2=R3=RF, the gain of the circuit becomes unity. Then, the output voltage is;

$$V0 = V2 - V1$$

If we choose the resistances as R1=R2 and R3=RF, the output voltage is multiplied by the gain of the inverting amplifier and becomes;

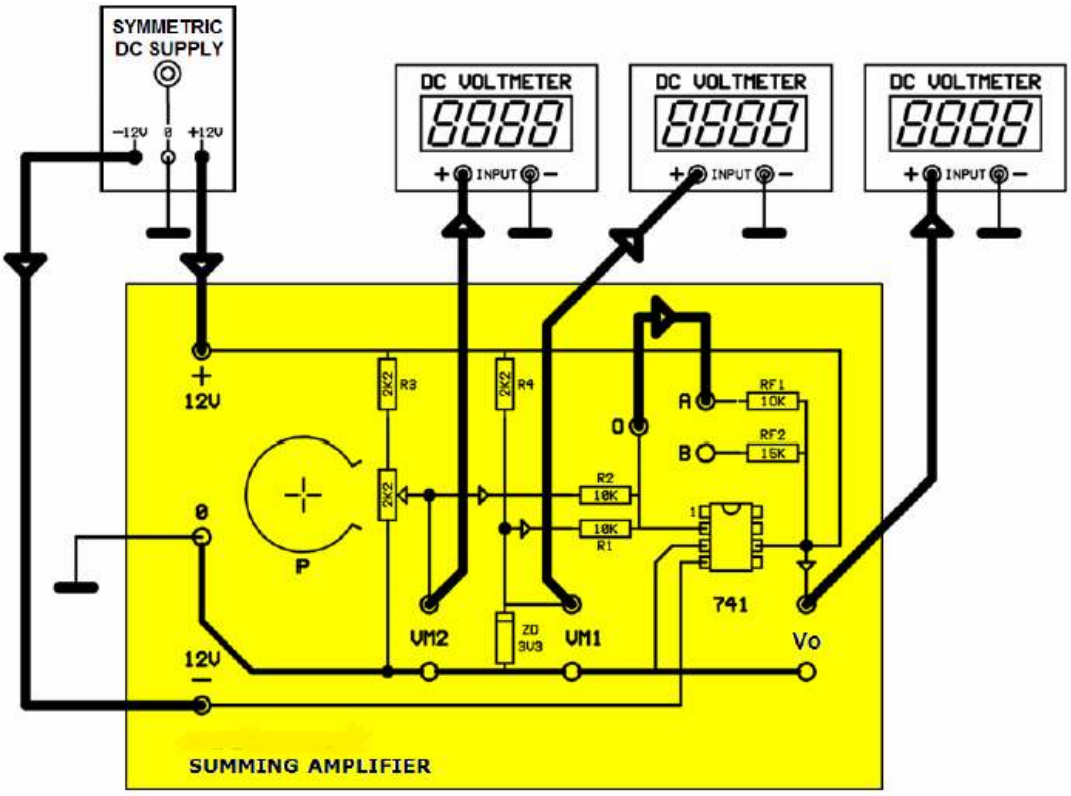
$$V0 = (V2 - V1) \cdot \frac{RF}{R1}$$

The sign of the output is the sign of the input terminal with the bigger input signal. If the signal at the inverting amplifier is greater, the output is negative; if the signal at the non-inverting amplifier is greater, the output is positive.

EXPERIMENT 2.1 ANALYZING SUMMING AMPLIFIER

EXPERIMENTAL PROCEDURE:

Connect the circuit as shown in the following figure.



In the experiment, one of the voltages (**V1**) is constant and the other one (**V2**) is variable.

1. Apply power to the circuit. Measure the voltage VM1. Take note of the voltage VM1 on Table 1 in each step. Adjust the voltage VM2 by using the potentiometer P in each step. Take note of the output voltage.

VM1 (Volt)	VM2 (Volt)	V0 (Volt)

Table 1

2. Does the summing circuit sum the input voltages?

3. Does the summing circuit operate as inverting amplifier?

4. Calculate the gain of the circuit.

5. Open the short circuit between the points O-A and short circuit the points O-B. Take note of the output voltage for the given voltage values V1 and V2 on Table 2.

VM1 (Volt)	VM2 (Volt)	V0 (Volt)

Table 2

6. Calculate the gain of the circuit.

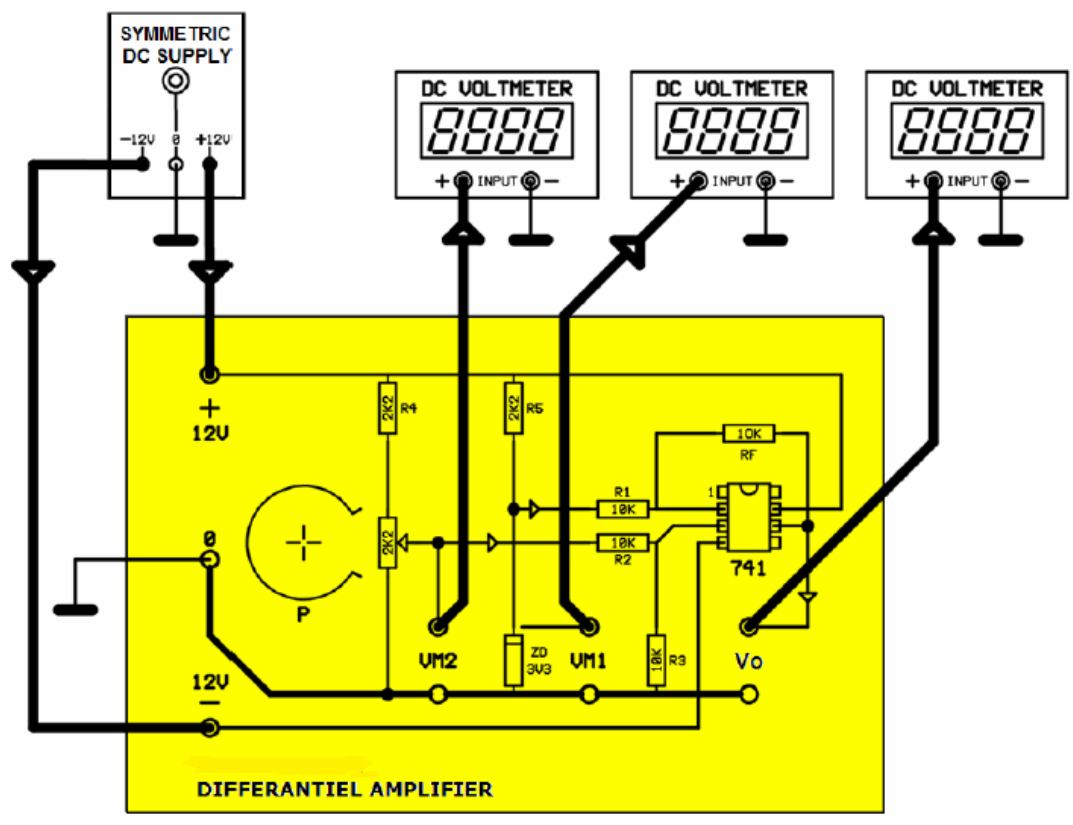
7. Did the summing circuit perform summation in each step?

EXPERIMENT 2.1 ANALYZING DIFFERENTIAL AMPLIFIER

The preliminary information has been given above.

EXPERIMENTAL PROCEDURE:

Connect the circuit as shown in the following figure.



In the experiment, one of the voltages (**VM1**) is constant and the other one (**VM2**) is variable.

1. Apply power to the circuit. Measure the voltage VM1. Take note of the voltage VM1 on Table 1 in each step. Adjust the voltage VM2 by using the potentiometer P in each step. Take note of the output voltage.

VM1 (Volt)	VM2 (Volt)	V0 (Volt)

Table 1

2. Does the differential circuit perform subtraction.

3. Calculate the gain of the circuit.

4. How is the sign of the output determined?

5. Fort the input voltages given in step 1, calculate the output voltage assuming R1=R2=10K and R3=RF=20K.