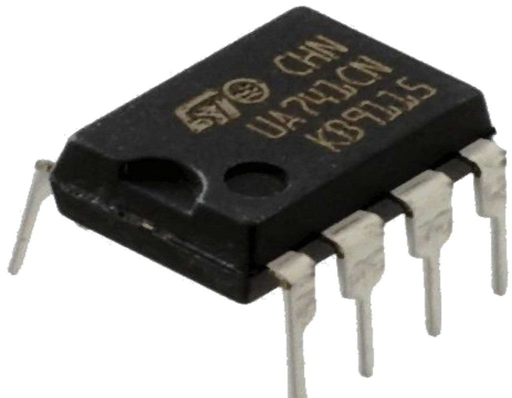
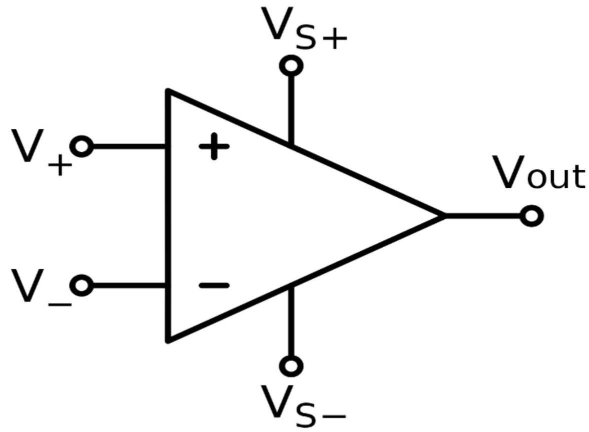
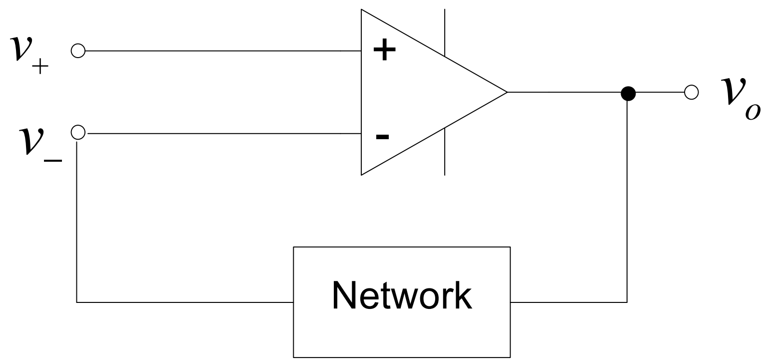
Chapter Four
Operational Amplifiers (OP-Amp





Chapter Outline: -

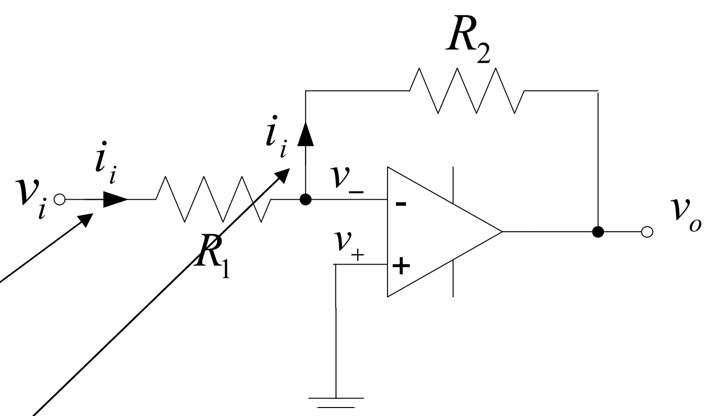
4.1 Ideal Op Amp



Golden Rules of Op Amps:

1. The output attempts to do whatever is necessary to make the voltage difference between the inputs zero.
2. The inputs draw no current.

4.2 Inverting Amplifier



Current into op amp is zero

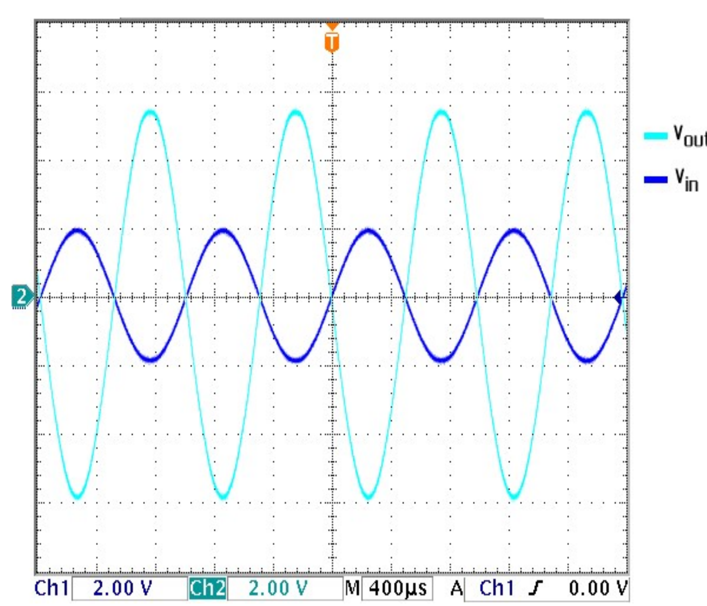
$$v_- = v_+ = 0$$

$$i_i = \frac{v_i - 0}{R_1} = \frac{v_i}{R_1}$$

$$i_i = \frac{0 - v_0}{R_2} = \frac{-v_0}{R_2}$$

$$\frac{v_i}{R_1} = \frac{-v_0}{R_2}$$

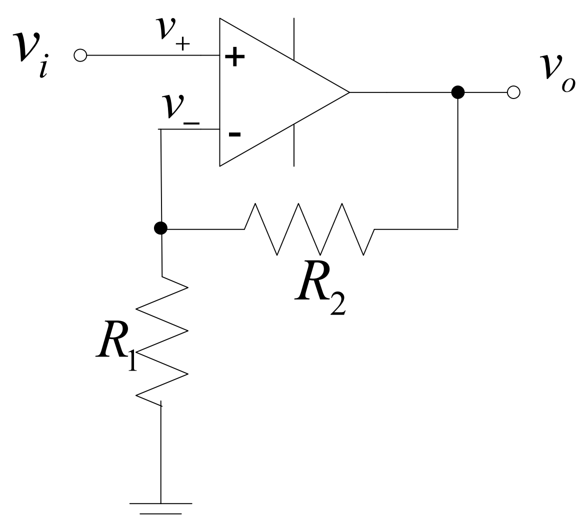
$$A_F = \frac{v_o}{v_i} = -\frac{R_2}{R_1}$$



4.3 Non-inverting Amplifier

Current into op amp is zero

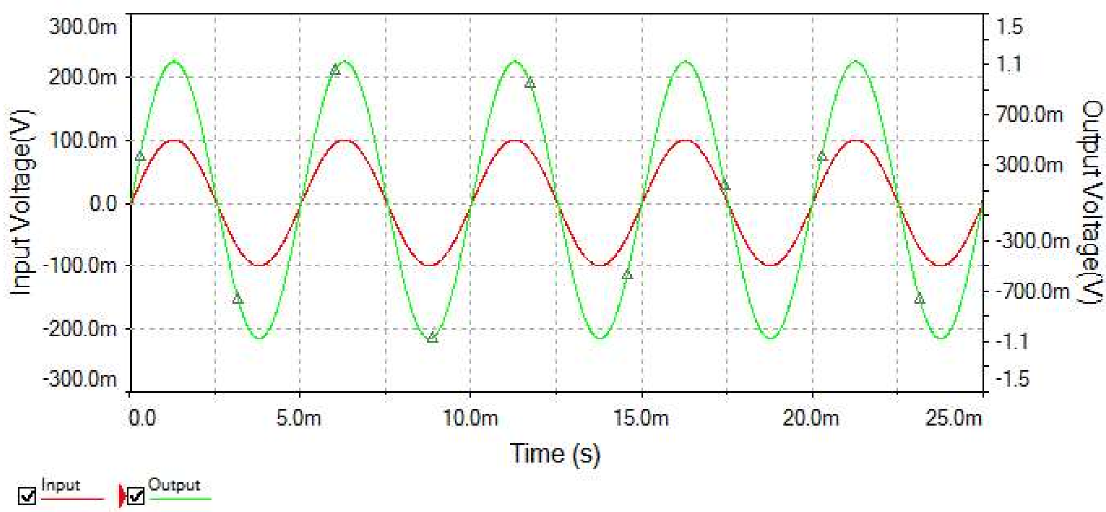
$$v_+ = v_- = v_i$$



$$A_F = \frac{v_o}{v_i}$$

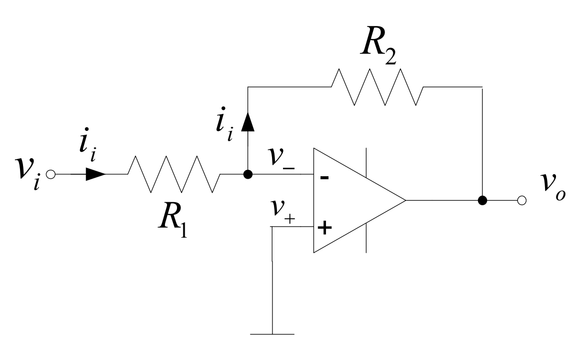
$$v_i = v_+ = v_- = \frac{R_1}{R_1 + R_2} v_o$$

$$A_F = \frac{v_o}{v_i} = 1 + \frac{R_2}{R_1}$$



EX. For the inverting Op-Amp in bellow. Find the gain voltage if vi=5v, R1=2Ω and R2 = 10Ω

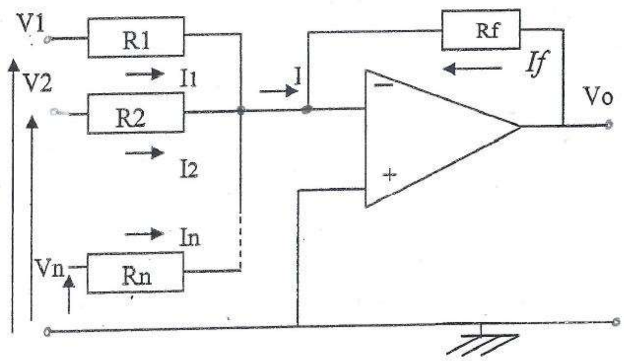
$$A_F = \frac{v_o}{v_i} = -\frac{R_2}{R_1}$$



$$A_F = \frac{10}{2} = 5$$

4.4 Summing OP-AMP

It is one of the inverting op-amp applications where the inverting input is connected to several voltage sources [V_1, V_2,… V_n]; n= number of inputs, as shown in the Figure above.



$$I = -I_F = I_1 + I_2 + \cdots + I_n \quad (1)$$

$$I_F = \frac{V_O}{R_F} \quad (2)$$

$$I_1 = \frac{V_1}{R_1} \quad (3)$$

$$I_2 = \frac{V_2}{R_2} \quad (4)$$

$$I_n = \frac{V_n}{R_n} \quad (5)$$

Sub. In equation (1) yields:-

$$I = \frac{V_O}{R_F} = -\left[\frac{V_1}{R_1} + \frac{V_2}{R_2} + \cdots + \frac{V_n}{R_n}\right] \quad (6)$$

So, the output voltage

$$V_O = -[\tfrac{R_1}{R_F} V_1 + \tfrac{R_2}{R_F} V_2 + \cdots + \tfrac{R_n}{R_F} V_n] \quad (7)$$

EX: Design op-amp summing circuit to solve the following equaions:-

1) $V_O = 0.2V_1 + V_2 - 0.2V_3$
2) $V_O = 2V_1 - 0.5V_2 - 0.4V_3$ (homework)
3) $V_O = 2.5V_1 - 0.2V_2$ (homework)

   Consider the feedback resistance is equal to 10KΩ

SOL.

بما انة دائرة الجامع هي من تطبيقات المكبر القالب , يجب اعتبار قطبية الفولتيات عكس الإشارة الجبرية بالمعادلة عند رسم الدائرة .

المعادلة الأولى تحتوي على ثلاثة حدود (n=3)

$R_F = 10K\Omega$ by using eq (7) we get:-

$$V_O = -\left[\frac{R_1}{R_F} V_1 + \frac{R_2}{R_F} V_2 + \cdots + \frac{R_n}{R_F} V_n\right]$$