Chapter 3 : Algebraic Operations

Basic Knowledges.

1. physical Illustration:

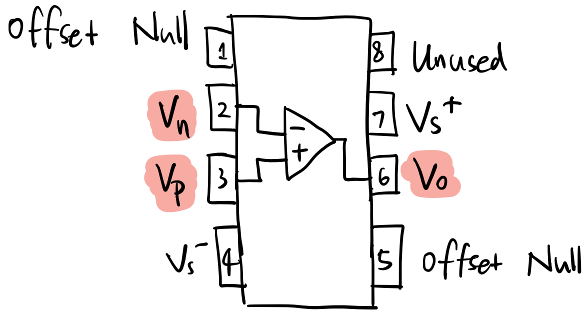
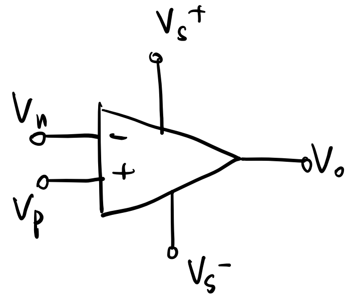


Diagram :



Important Terminals

- Input : V_n, V_p
- Output : V_o
- power : V_s^-, V_s^+

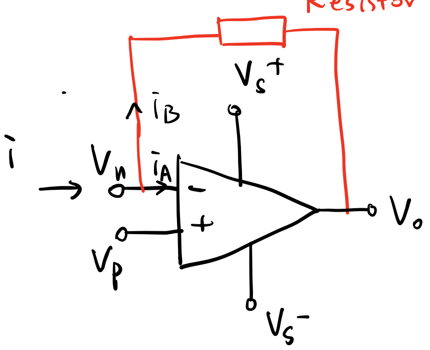
2. Open loop Connection

Δ gain K $\Rightarrow$ $V_o = K(V_p - V_n)$ and $|V_o| \leq V_s^+$

Saturation

3. Closed loop Connection (Feed back Configuration)

Resistor / Capacitor / nothing



Two facts : $i_A \overset{\approx}{=} 0$ ($\frac{1}{1000} i$), $V_n \overset{\approx}{=} V_p$

Experimental

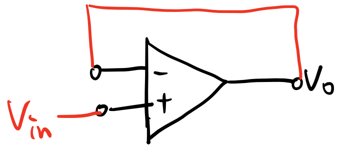
☆ Only exist in the feedback configuration

$i = i_A + i_B$ and $i_A = 0$

$$\frac{V_n - V_o}{R} = i_B \Rightarrow V_o = V_n - i_B R$$

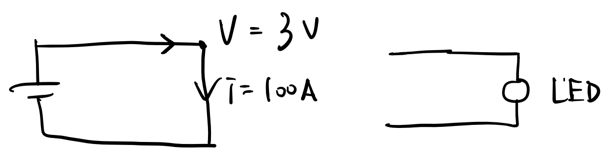
4. Basic circuits

① Buffering / Cascading

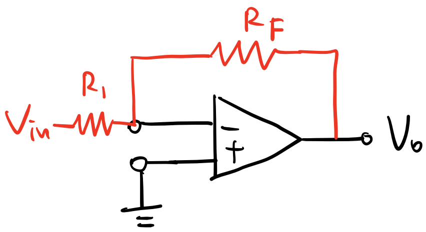


$V_{in} = V_o$

It seems like a direct wire connection.



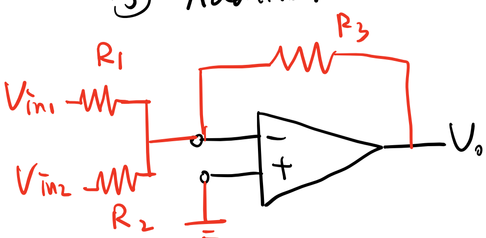
② Gain and Inverting



$$\frac{0 - V_o}{R_F} = \frac{V_{in}}{R_1} \Rightarrow V_o = -\frac{R_F}{R_1} V_{in}$$

$-$ → invert; $\frac{R_F}{R_1}$ → gain

③ Addition



$$\frac{V_{in1} - 0}{R_1} + \frac{V_{in2} - 0}{R_2} = \frac{0 - V_o}{R_3}$$

$$\Rightarrow V_o = -\left(\frac{R_3}{R_1} V_{in1} + \frac{R_3}{R_2} V_{in2}\right)$$

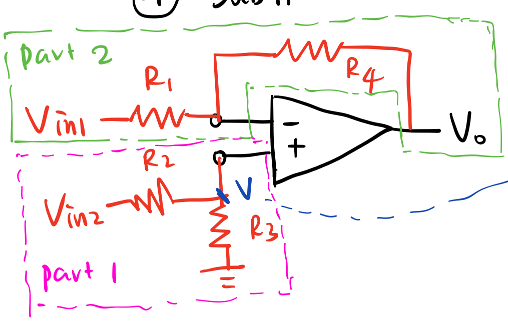
If $R_1 = R_2 = R$

$$\Rightarrow V_o = -\frac{R_3}{R}(V_{in1} + V_{in2})$$ Addition

If $R_1 = R_2 = R_3 = R$

$$\Rightarrow V_o = -(V_{in1} + V_{in2})$$

④ Subtraction



Denote the voltage V

part 1: $$\frac{V_{in2} - V}{R_2} = \frac{V}{R_3}$$

$$\Rightarrow \frac{V_{in2}}{R_2} = \left(\frac{1}{R_2} + \frac{1}{R_3}\right) V$$

$$\Rightarrow V = \frac{R_2 R_3}{R_2 + R_3} \cdot \frac{V_{in2}}{R_2} = \frac{R_3}{R_2 + R_3} V_{in2}$$

part 2: $$\frac{V_{in1} - V}{R_1} = \frac{V - V_o}{R_4}$$

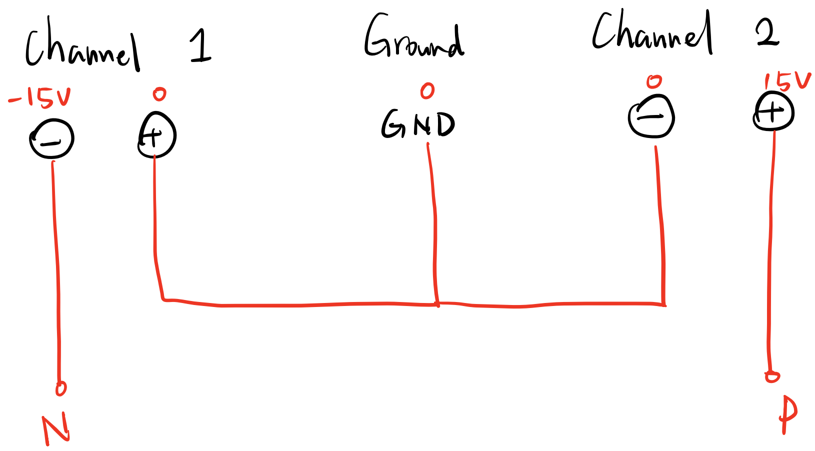
Sub. V

$$\Rightarrow V_o = \left(\frac{R_4}{R_1} + 1\right) V - \frac{R_4}{R_1} V_{in1} = \left(\frac{R_4}{R_1} + 1\right) \frac{R_3}{R_2 + R_3} V_{in2} - \frac{R_4}{R_1} V_{in1} = -(V_{in1} - V_{in2})$$

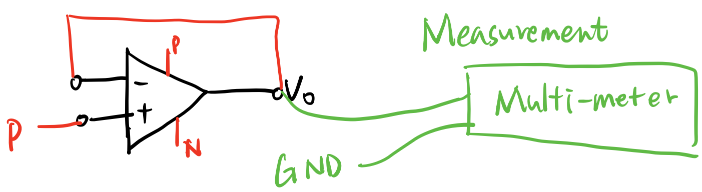
(if $R_1 = R_2 = R_3 = R_4 = R$)

Experiments Steps.

① Set up the power source

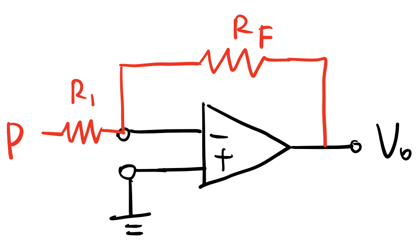


② A. To buffer +15V



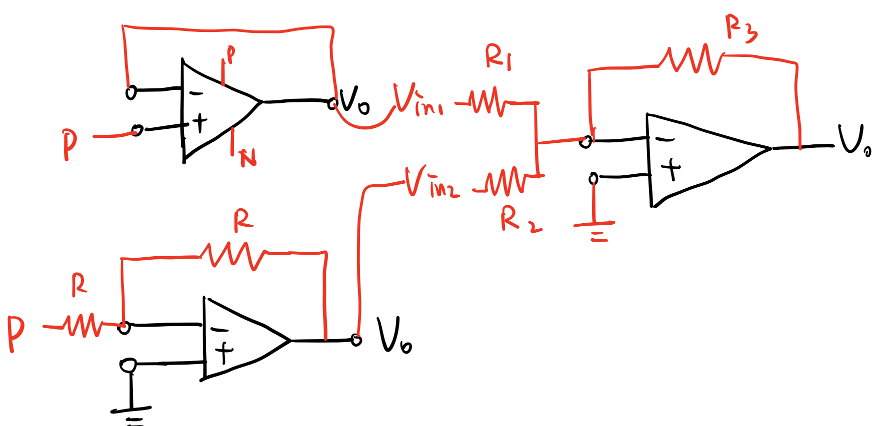
$V_o = P$

B. To step down from +15 V



$$V_o = -\frac{R_F}{R_1} P$$

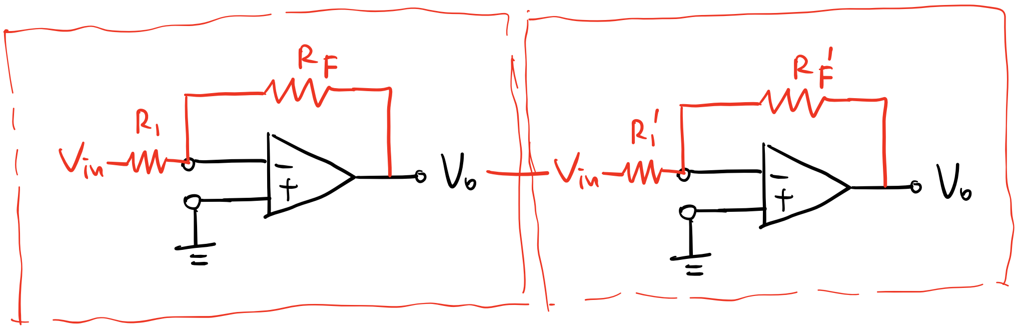
C. To sum the A and B outputs



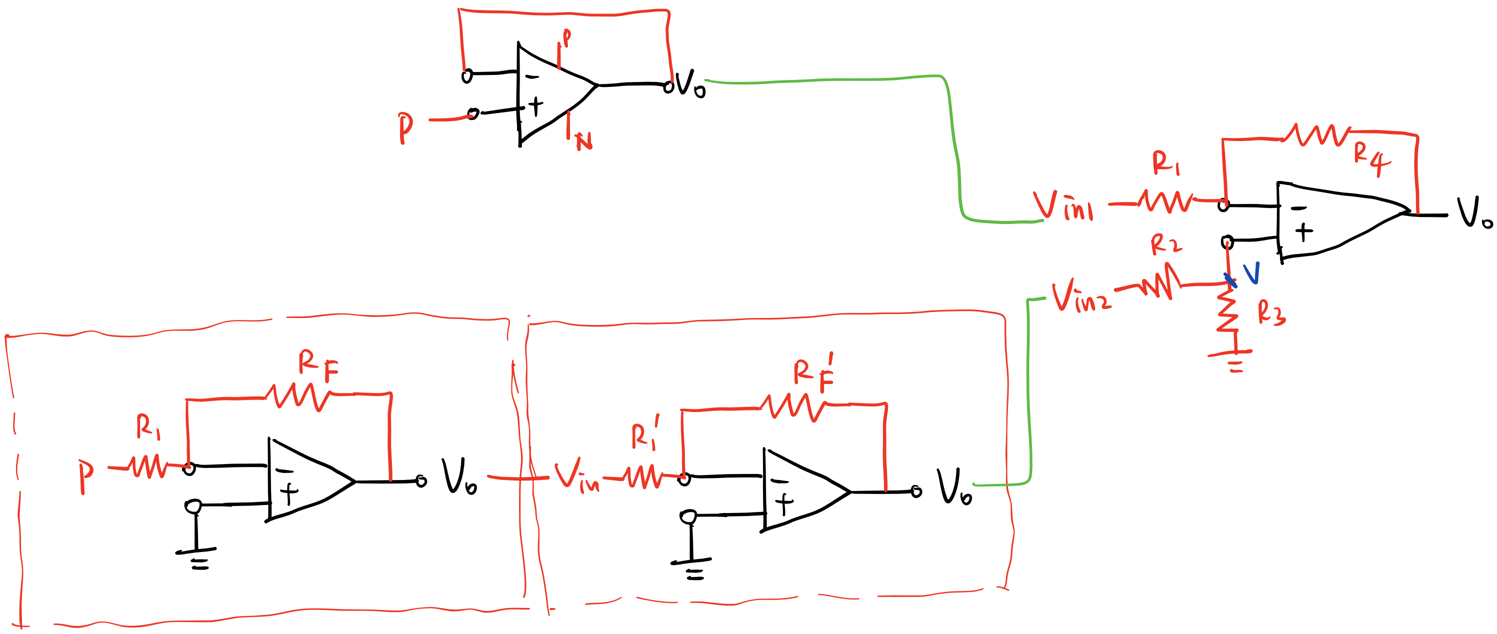
If $R_1 = R_2 = R_3 = R$

$\Rightarrow V_o = -(V_{in1} + V_{in2})$

D. To invert the B output



E. To substract the D output from the A output (A − D)



F. To get an output of 3V from the +15V input

Hints: use the parallel or series of resistors to create an "equivalent resistor" with new resistance value.