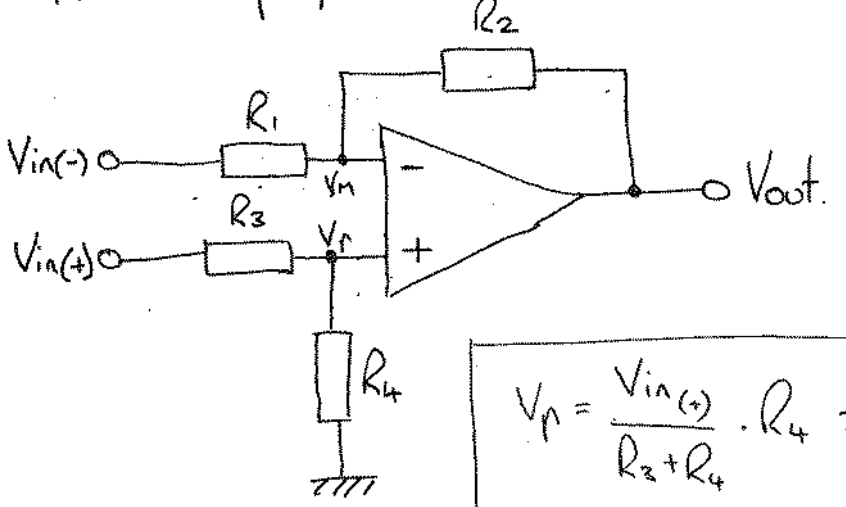
Difference Amplifier



$V = IR$ ①

$\frac{V}{I} = R$

$\frac{V}{R} = I$

$V_p = \frac{V_{in(+)}}{R_3 + R_4} \cdot R_4$ *

$V_{out} = A(V_p - V_m)$

$I_{R1} - I_{R2} = 0$

$I_{R1} = \frac{V_{in(-)} - V_m}{R_1}$

$I_{R2} = \frac{V_m - V_{out}}{R_2}$

$V_p = I_{R3} \cdot R_4$

$I_{R3} = \frac{V_{in(+)}}{R_3 + R_4}$

$\frac{V_{in(-)} - V_m}{R_1} - \frac{V_m - V_{out}}{R_2} = 0$ ⌐ $\frac{V_{in(-)}}{R_1(R_1+R_2)} + \frac{V_{out}}{R_2(R_1+R_2)} = \frac{V_m}{R_1 \cdot R_2}$

$\frac{V_{in(-)}}{R_1} - \frac{V_m}{R_1} - \frac{V_m}{R_2} + \frac{V_{out}}{R_2} = 0$ $V_m = \frac{V_{in(-)} R_1 R_2}{R_1(R_1+R_2)} + \frac{V_{out} R_1 R_2}{R_2(R_1+R_2)}$

$\frac{V_{in(-)}}{R_1} + \frac{V_{out}}{R_2} = \frac{V_m}{R_1} + \frac{V_m}{R_2}$ $= \frac{V_{in(-)} R_2}{R_1 + R_2} + \frac{V_{out} R_1}{R_1 + R_2}$

$\frac{V_{in(-)}}{R_1} + \frac{V_{out}}{R_2} = \frac{V_m R_2 + V_m R_1}{R_1 \cdot R_2}$ $V_m = \frac{V_{in(-)} R_2 + V_{out} R_1}{R_1 + R_2}$ *

$\frac{V_{in(-)}}{R_1} + \frac{V_{out}}{R_2} = \frac{V_m(R_1+R_2)}{R_1 \cdot R_2}$ ⌐

$V_{out} = A(V_p - V_m)$

$V_{out} = A\left(\frac{V_{in(+)} R_4}{R_3+R_4} - \frac{V_{in(-)} R_2 + V_{out} R_1}{R_1 + R_2}\right)$ ⌐ $V_{in(-)} R_2 + V_{out} R_1 = \frac{V_{in(+)} R_4 (R_1+R_2)}{R_3+R_4}$

$V_{out} R_1 = \frac{V_{in(+)} R_4 (R_1+R_2)}{R_3+R_4} - V_{in(-)} R_2$

$\frac{V_{out}}{A} = \frac{V_{in(+)} R_4}{R_3+R_4} - \frac{V_{in(-)} R_2 + V_{out} R_1}{R_1 + R_2}$ $V_{out} R_1 = \frac{V_{in(+)} R_4 (R_1+R_2) - V_{in(-)} R_2 (R_3+R_4)}{R_3+R_4}$

$A \to \infty \therefore \frac{V_{out}}{A} \to 0$ ⇒ $V_{out} = \frac{V_{in(+)} R_4 (R_1+R_2) - V_{in(-)} R_2 (R_3+R_4)}{R_1 (R_3+R_4)}$

$\frac{V_{in(-)} R_2 + V_{out} R_1}{R_1 + R_2} = \frac{V_{in(+)} R_4}{R_3+R_4}$ ⌐

$$V_{out} = \frac{V_{in(+)} R_4 (R_1 + R_2) - V_{in(-)} R_2 (R_3 + R_4)}{R_1 (R_3 + R_4)}$$

If; $V_{in(+)} = V_{in(-)} = V_{in}$ then;

$$V_{out} = \frac{V_{in} R_4 (R_1 + R_2) - V_{in} R_2 (R_3 + R_4)}{R_1 (R_3 + R_4)}$$

$$\frac{V_{out}}{V_{in}} = \frac{R_4 (R_1 + R_2) - R_2 (R_3 + R_4)}{R_1 (R_3 + R_4)}$$

$$= \frac{R_4 (R_1 + R_2)}{R_1 (R_3 + R_4)} - \frac{R_2 (R_3 + R_4)}{R_1 (R_3 + R_4)}$$

$$\frac{V_{out}}{V_{in}} = \frac{R_4 (R_1 + R_2)}{R_1 (R_3 + R_4)} - \frac{R_2}{R_1} \Leftarrow$$

(2)

$$V_{out} = A (V_1 - V_n)$$

$$V_{out} = A \left(\frac{V_{in(+)} R_4}{R_3 + R_4} - \frac{V_{in(-)} R_2 + V_{out} R_1}{R_1 + R_2} \right)$$

$$\frac{V_{out}}{A} = \frac{V_{in(+)} R_4}{R_3 + R_4} - \frac{V_{in(-)} R_2 + V_{out} R_1}{R_1 + R_2}.$$

$$\frac{V_{out}}{A} + \frac{V_{in(-)} R_2 + V_{out} R_1}{R_1 + R_2} = \frac{V_{in(+)} R_4}{R_3 + R_4}$$

$$\frac{V_{out}(R_1 + R_2) + V_{in(-)} A R_2 + V_{out} A R_1}{A (R_1 + R_2)} = \frac{V_{in(+)} R_4}{R_3 + R_4}$$

$$\frac{V_{out}(R_1 + R_2 + A R_1) + V_{in(-)} A R_2}{A (R_1 + R_2)} = \frac{V_{in(+)} R_4}{R_3 + R_4}$$

$$V_{out}(R_1 + R_2 + A R_1) + V_{in(-)} A R_2 = \frac{V_{in(+)} R_4 A (R_1 + R_2)}{R_3 + R_4}$$

$$V_{out}(R_1 + R_2 + A R_1) = \frac{V_{in(+)} R_4 A (R_1 + R_2)}{R_3 + R_4} - V_{in(-)} A R_2$$

$$= \frac{V_{in(+)} R_4 A (R_1 + R_2) - V_{in(-)} R_2 A (R_3 + R_4)}{R_3 + R_4}$$

$$V_{out} = \frac{V_{in(+)} R_4 A (R_1 + R_2) - V_{in(-)} R_2 A (R_3 + R_4)}{(R_3 + R_4)(R_1 + R_2 + A R_1)} \Leftarrow$$