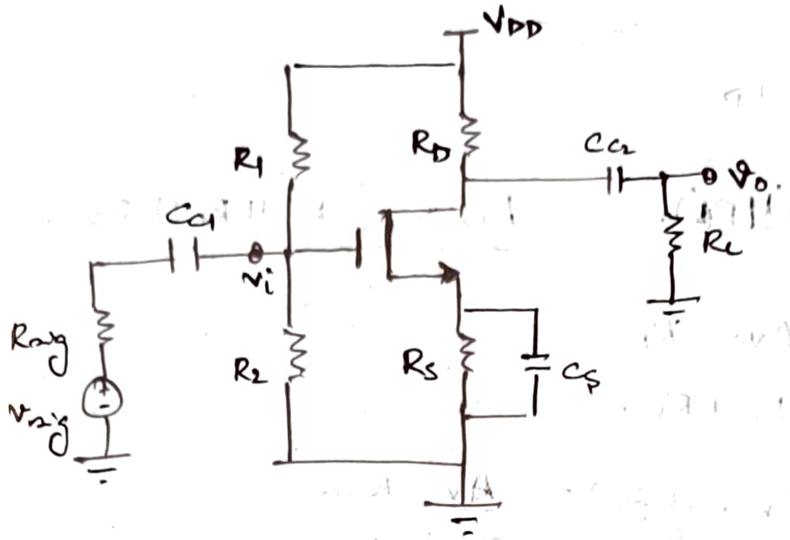
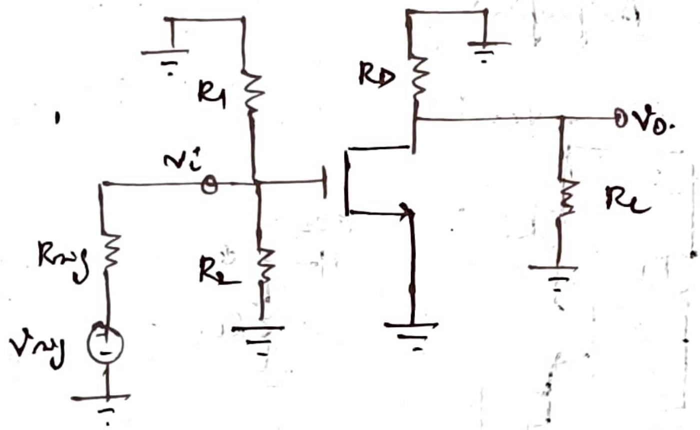
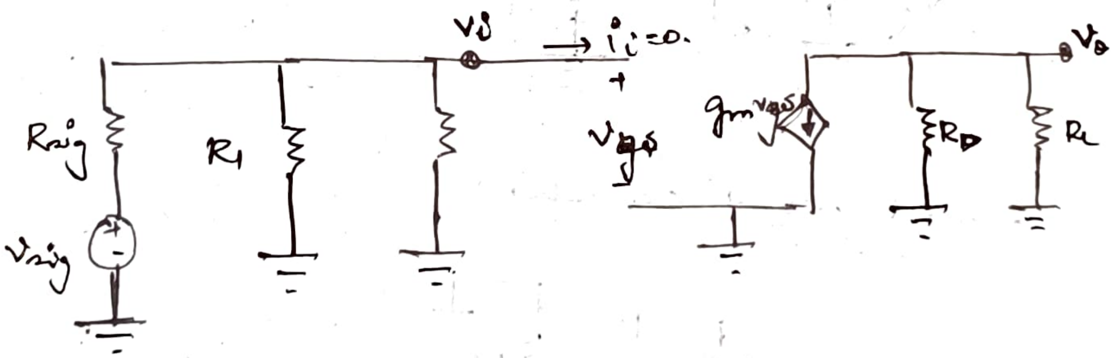
Common Source Amplifier:



Small Signal Equivalent Model:





$$v_o = (-g_m v_{gs}) * (R_D \parallel R_L).$$

when $R_L \to \infty$.

$$v_o = (-g_m R_D)\, v_i$$

$$\Rightarrow A_{vo} = -g_m R_D$$

$\because i_i = 0 \Rightarrow R_i = \frac{v_i}{i_i} = \infty.$

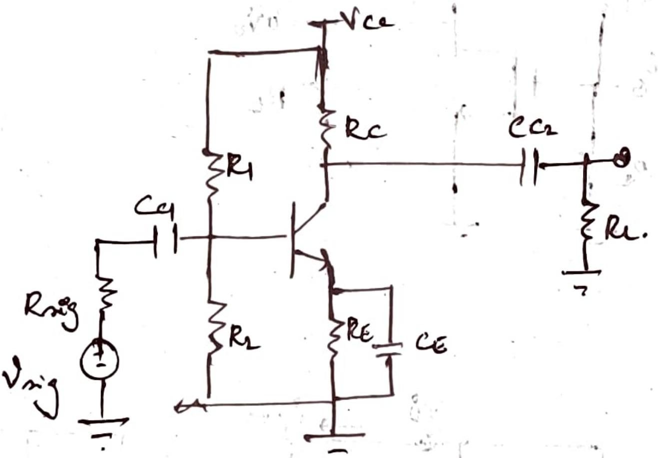
$R_o = R_D.$

$R_{out} = (R_o \| R_L).$ $R_{in} = (R_i \| R_1 \| R_2).$

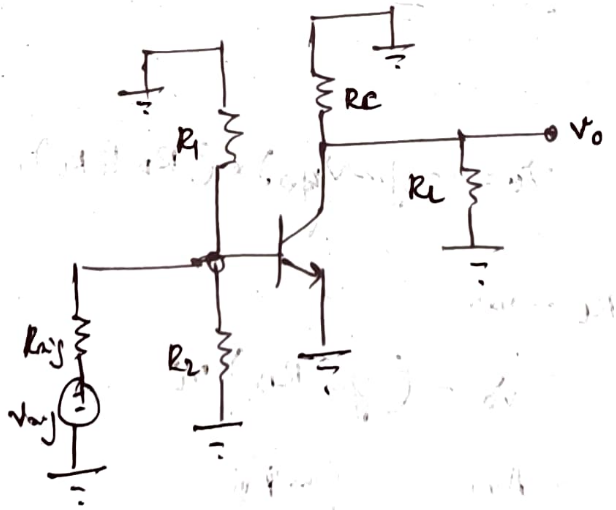
$$A_v = \frac{A_{vo} \cdot R_L}{R_o + R_L}.$$

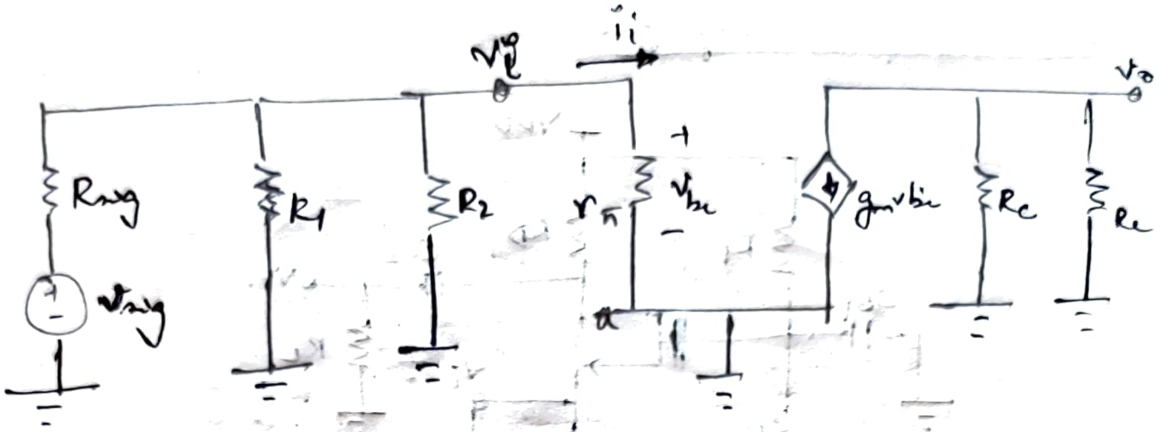
$$G_v \text{ (net gain)} = \frac{A_v \cdot R_{in}}{R_{in} + R_{sig}}.$$

Common Emitter Amplifier



Small signal equivalent :





$$v_o = (-g_m v_{be})\,[R_C \parallel R_L]$$

when $R_L \to \infty$.

$$A_{vo} = -(g_m R_C).$$

$$R_o = R_C$$

$$R_i = \frac{v_i}{i_i} = r_\pi$$

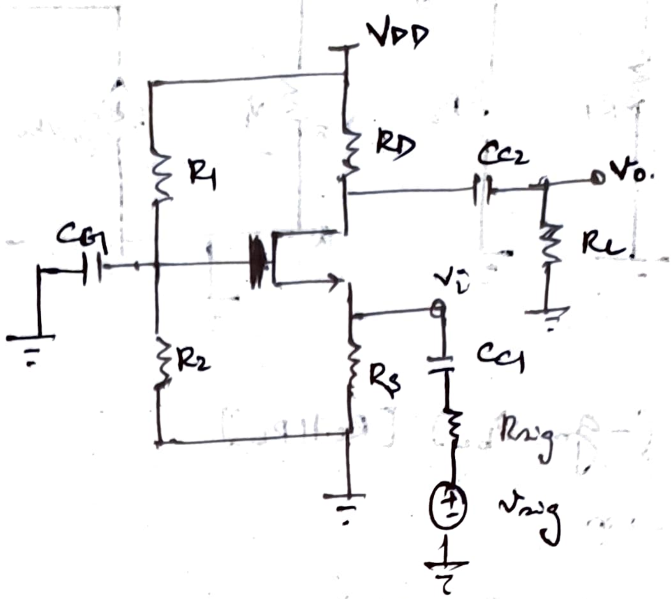
$$A_v = \cancel{A_{vo}\,(R_o \parallel R_L)}.\ A_{vo} \cdot \frac{R_L}{R_o + R_L}$$

$$R_{in} = (R_i \parallel R_1 \parallel R_2).$$

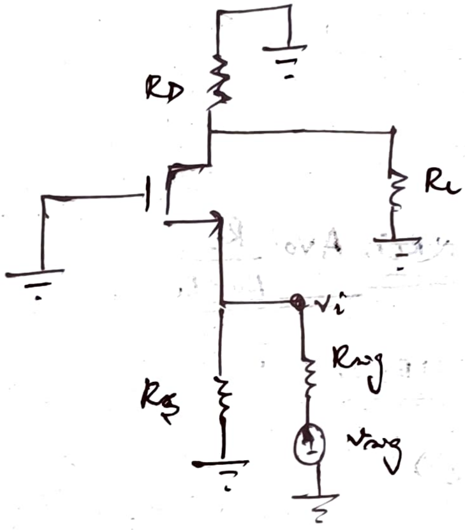
$$R_{out} = (R_o \parallel R_L)$$

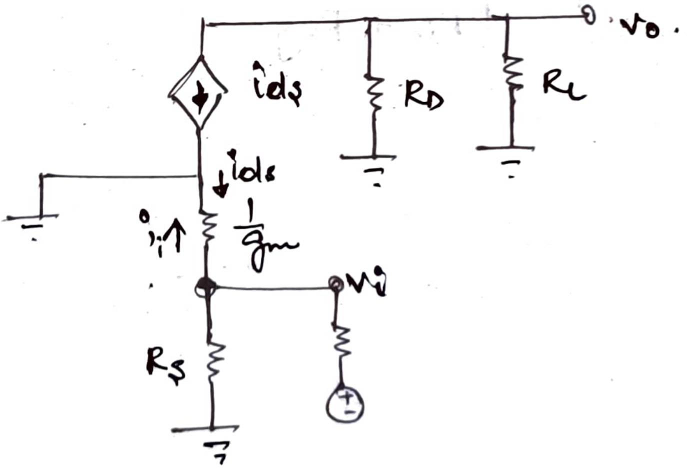
$$G_v = \frac{A_v\,(R_{in})}{R_{in} + R_{sig}}$$

Common Gate Amplifier



Small Signal Equivalent.





$i_i = -i_{ds} = ~~v_i g_m~~ - g_m v_i$

$v_o = (-i_{ds})(R_D \| R_L)$

when $R_L \to \infty$.

$v_o = g_m v_i R_D$

$\Rightarrow A_{vo} = g_m R_D$

$R_i = 1/g_m$ → Small value. Hence, not prefer

$R_o = R_D$

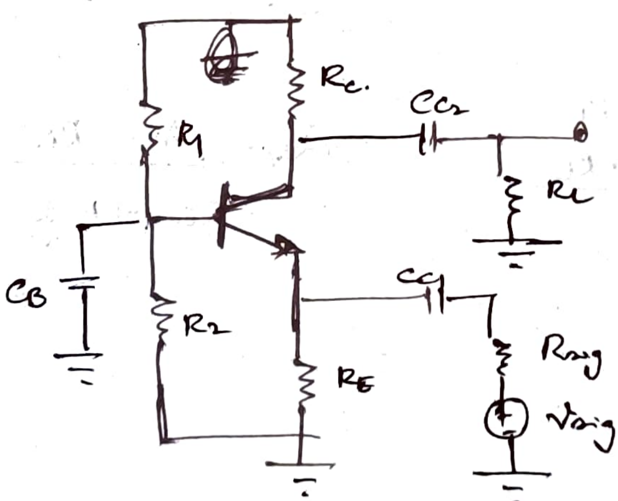
$R_{in} = (R_i \| R_S)$.

$R_{out} : (R_o \| R_L)$

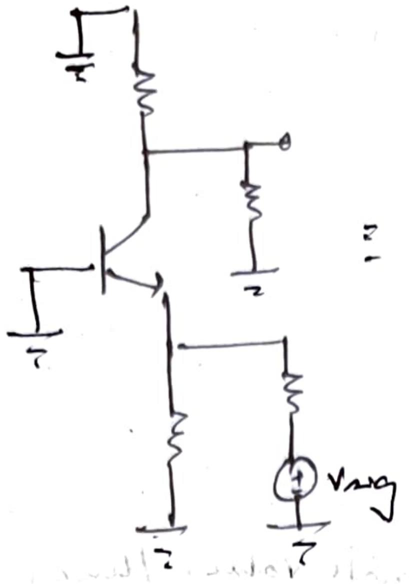
$$A_v = \frac{A_{vo} R_L}{R_L + R_O}$$

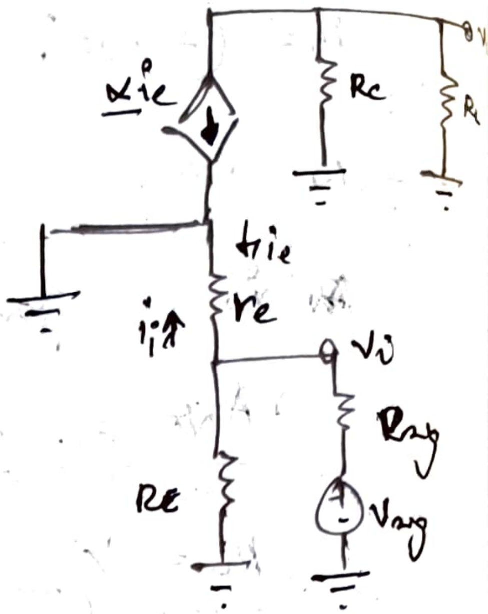
$$G_v = \frac{A_v \cdot R_{in}}{R_{in} + R_{sig}}$$

Common Base Amplifier



Small Signal Equivalent Model.





$$i_i = -i_e = \frac{v_i}{r_e}.$$

$$\Rightarrow v_o = (-i_i)(R_C \,||\, R_L) = g_m (R_C \,||\, R_L)\, v_i$$

When $R_L \rightarrow \infty$.

$$A_{vo} = g_m R_C$$

$$R_i = r_e = \frac{\alpha}{g_m}$$

$$R_{in} = (R_i \,||\, R_E).$$

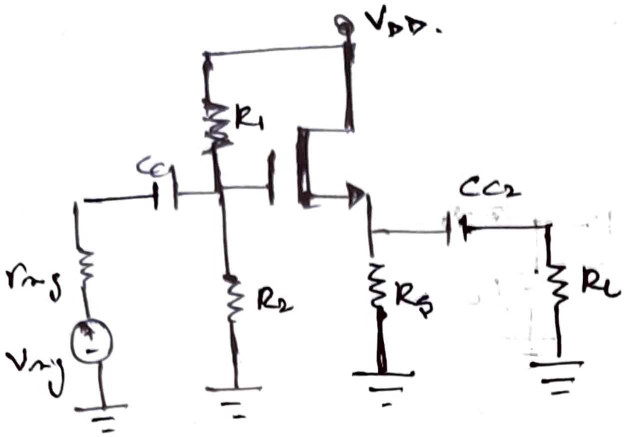
$$R_o = R_C$$

$$R_{out} = R_o \,||\, R_L$$

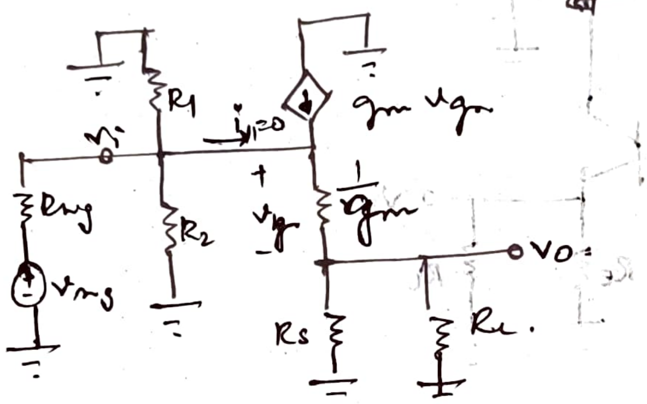
$$A_v = \frac{A_{vo} \cdot R_L}{R_o + R_L}$$

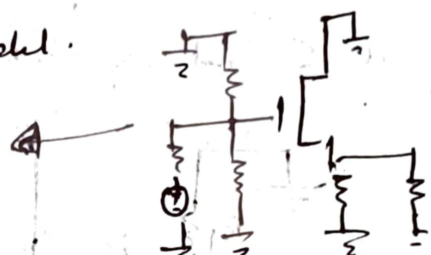
$$G_v = \frac{A_v \cdot R_{in}}{R_{in} + R_{sig}}$$

Common Drain Amplifier:



Small Signal Equivalent Model.





$$i = (g_m v_{gs}).$$

$$v_o = i(R_S \| R_L).$$

$$v_i = i\left(\frac{1}{g_m} + (R_S \| R_L)\right).$$

$$\Rightarrow \quad A_v = \frac{(R_S \| R_L)}{\frac{1}{g_m} + (R_S \| R_L)} = \frac{g_m (R_S \| R_L)}{1 + g_m (R_S \| R_L)}.$$

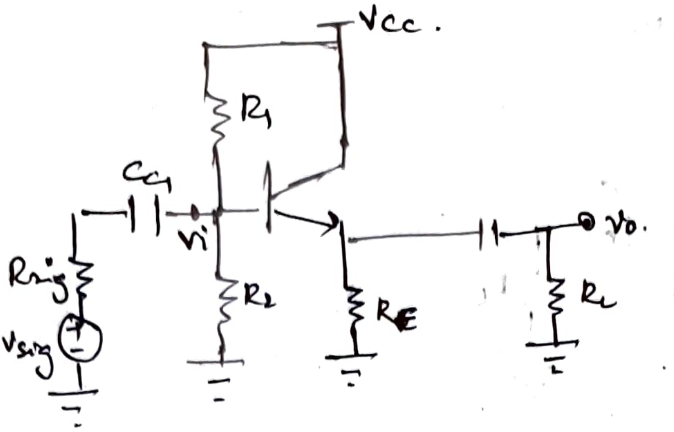
$$R_o = 1/g_m. \qquad R_i = \infty.$$

$$A_{vo} = \frac{g_m R_S}{1 + g_m R_S}. \qquad R_{in} = (R_i \| R_1 \| R_2)$$

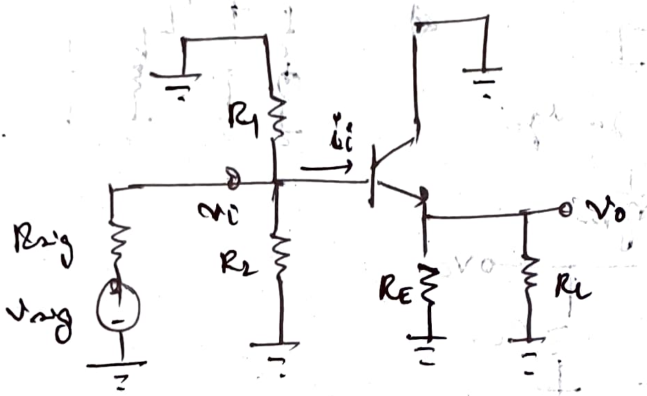
$$R_{out} = (R_o \| R_S)$$

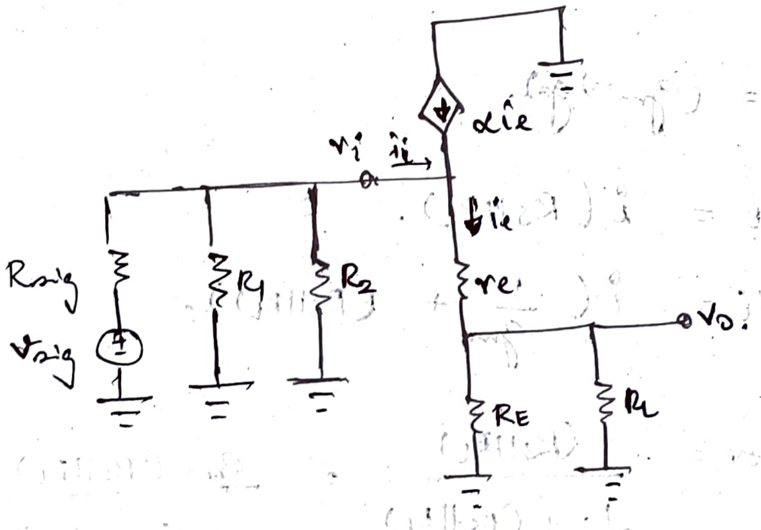
$$G_v = \frac{A_v \cdot R_{in}}{R_{in} + R_{sig}}$$

Common Collector Circuit:



Small Signal Equivalent Model.





$$i_e = (\beta+1) i_i.$$

$$V_o = i_e (R_E \| R_L).$$

$$V_i = i_e (r_e + (R_E \| R_L))$$

$$\frac{V_o}{V_i} = \frac{(R_E \| R_L)}{r_e + R_E \| R_L} = \frac{g_m (R_E \| R_L)}{\alpha + g_m (R_E \| R$$

$$R_o = r_e = \frac{\alpha}{g_m}.$$

$$R_i = (\beta+1)[r_e + (R_E \parallel R_L)]$$

$$R_{out} = (R_o \parallel R_E)$$

$$R_{in} = (R_i \parallel R_1 \parallel R_2)$$

$$G_v = \frac{A_v \cdot R_{in}}{R_{sig} + R_{in}}$$

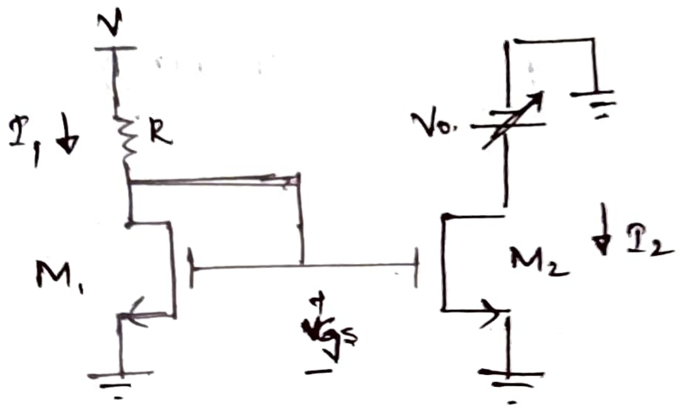
Note:

In Common Collector (aka Emitter Follower) and Common Drain (aka Source Follower), the gain is always <1. In the ideal case of ~~[illegible]~~ $(R_S \parallel R_L)$ or $(R_E \parallel R_L) \longrightarrow \infty$,

$A_v = 1$.

This kind of amplifier is used to generate a phase shifter with no gain.

Current Mirror:



M_1 and M_2 have same k_n' and L ↳ and hence same V_{thn}

Both are in saturation mode

$$I_1 = \frac{1}{2} k_n' \frac{W_1}{L} (V_{GS} - V_{thn})^2$$

For $V_o > V_{GS} - V_{thn}$

$$I_2 = \frac{1}{2} k_n' \frac{W_2}{L} (V_{GS} - V_{thn})^2$$

$$\Rightarrow \frac{I_1}{I_2} = \frac{W_1}{W_2}$$

when $W_1 = W_2$, $I_1 = I_2$.

This method is used to generate similar currents across multiple branches in an IC.

PS: If BJT's are used,

$$\frac{I_2}{I_1} = \frac{\lambda}{\beta(\lambda+1)+1} \quad (\text{where } \lambda = \frac{A_2}{A_1})$$