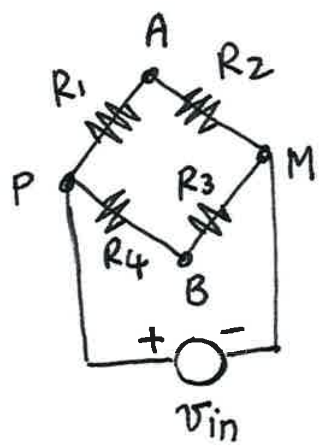
SYSTEMS OF EQUATIONS



WHEATSTONE BRIDGE

$v_{in} = 1V$

$R1 = 1k\Omega$

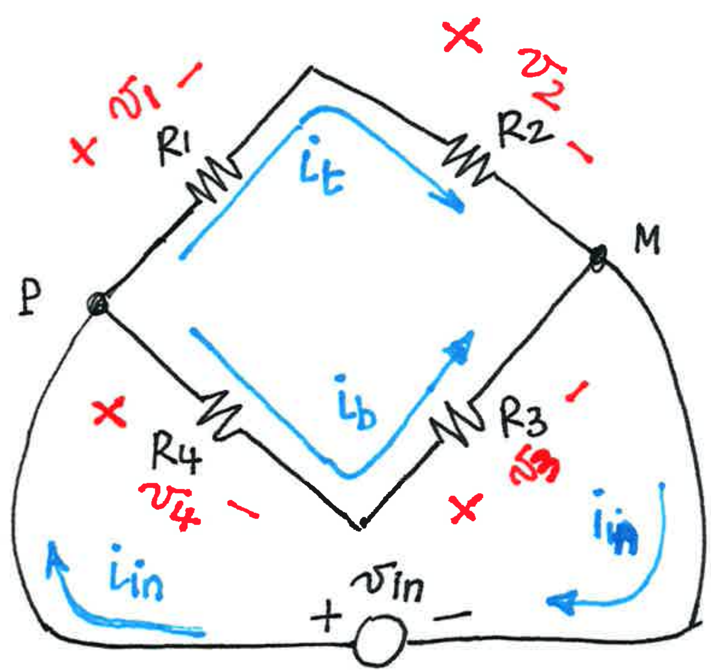
$R2 = 4k\Omega$

$R3 = 10k\Omega$

$R4 = \frac{10}{4} k\Omega = 2.5k\Omega$

i_t, i_b

v_1, v_2, v_3, v_4



$$\begin{cases} v_{in} = R_3 i_b + R_4 i_b \\ v_{in} = R_1 \cdot i_t + R_2 \cdot i_t \end{cases}$$

$$\updownarrow$$

$$\begin{cases} v_{in} = (R_3 + R_4) \cdot i_b \\ v_{in} = (R_1 + R_2) \cdot i_t \end{cases}$$

$$i_b = \frac{v_{in}}{R_3 + R_4} = \frac{1V}{12.5K} = 0.08mA$$

$$i_t = \frac{v_{in}}{R1+R2} = \frac{1V}{5K} = 0.2\,mA \qquad i_b = 0.08\,mA$$

$$i_{in} = i_t + i_b = 0.28\,mA \qquad R_1+R_2 = R_t = 5K\Omega$$

$$R_3+R_4 = R_b = 12.5K\Omega$$

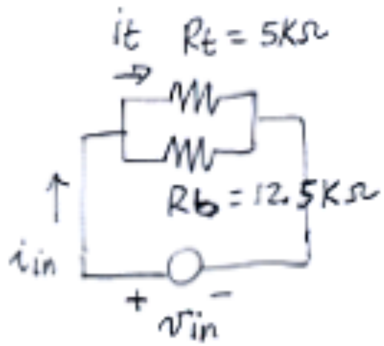
$$\left.\begin{aligned} v_1 &= i_t \cdot R_1 = 0.2V \\ v_2 &= i_t\, R_2 = 0.8V \end{aligned}\right\}$$

$$\left.\begin{aligned} v_3 &= i_b\, R_3 = 0.8V \\ v_4 &= i_b\, R_4 = 0.2V \end{aligned}\right\}$$

$$\begin{cases} v_{in} = 5K \cdot i_t \\ v_{in} = 12.5K \cdot i_b \end{cases} \longrightarrow \begin{cases} v_{in} = 5K \cdot i_t + 0 \cdot i_b \\ v_{in} = 0 \cdot i_t + 12.5K \cdot i_b \end{cases}$$

$$\longrightarrow \begin{cases} 1 = 5K \cdot i_t + 0 \cdot i_b \\ 1 = 0 \cdot i_t + 12.5K \cdot i_b \end{cases} \qquad b = A \cdot x$$

$$\underbrace{\begin{bmatrix} 1 \\ 1 \end{bmatrix}}_{b} = \underbrace{\begin{bmatrix} 5K & 0 \\ 0 & 12.5K \end{bmatrix}}_{A} \underbrace{\begin{bmatrix} i_t \\ i_b \end{bmatrix}}_{x} \longrightarrow x = A \backslash b \qquad \begin{aligned} 0.2\,mA &= i_t \\ 0.08\,mA &= i_b \end{aligned}$$



$$R_t \parallel R_b = R_{in} = \frac{R_t \cdot R_b}{R_t + R_b}$$

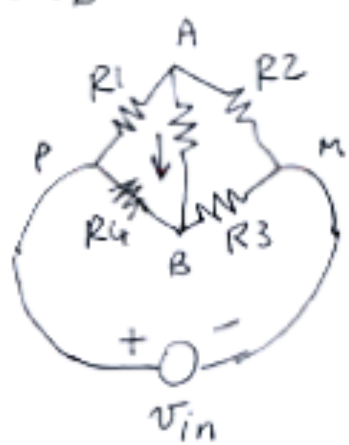
$$i_{in} = \frac{v_{in}}{R_{in}} = 0.28\ mA$$

$$i_t = \frac{i_{in}}{R_t + R_b} \cdot R_b \simeq 0.2\ mA$$

$$i_b = i_{in} - i_t = 0.28 - 0.2 = 0.08\ mA$$

- let's try to gather some insight about the circuit

$v_1 = v_4 \longrightarrow v_A = v_B$



$$v_1 = v_4$$
$$\updownarrow$$
$$v_3 = v_2$$

$$v_3 = v_{in} - v_4$$

$$v_2 = v_{in} - v_1$$

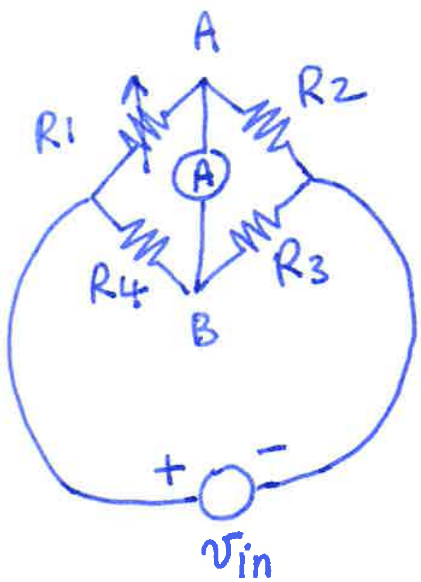
$$v_1 = R_1 \cdot i_t = v_4 = R_4 \cdot i_b \longrightarrow i_b = \frac{R_1}{R_4} \cdot i_t$$

$$v_3 = R_3 \cdot i_b = v_2 = R_2 \, i_t$$

$$\downarrow$$

$$R_3 \cdot \frac{R_1}{R_4} \cdot \cancel{i_t} = R_2 \cancel{i_t} \longleftrightarrow \boxed{R_3 R_1 = R_2 R_4}$$

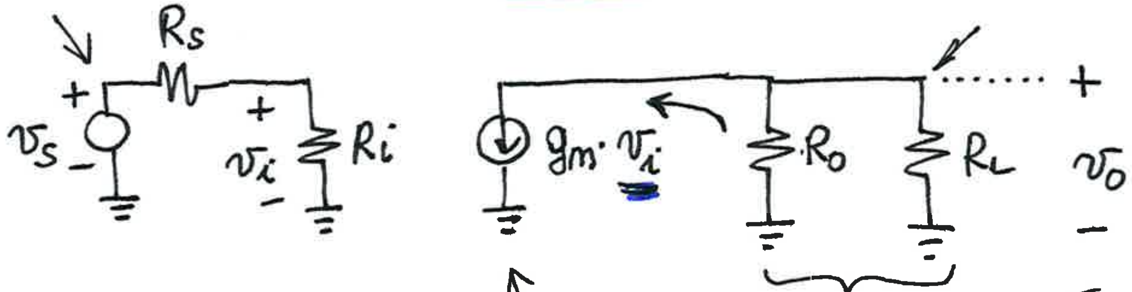
BALANCED WHEAT. BRIDGE



$$R_1 R_3 = R_2 R_4$$

$$R_3 = \frac{R_2 R_4}{R_1}$$

AMPLIFIER



dependent current source controlled voltage

AMPLIFIER

$$\frac{v_o}{v_s} = ? = A_v$$

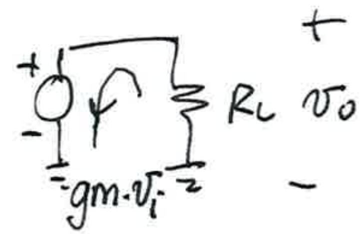
$$R = R_o \| R_L$$

$$v_i = \frac{v_s}{R_s + R_i} \cdot R_i$$

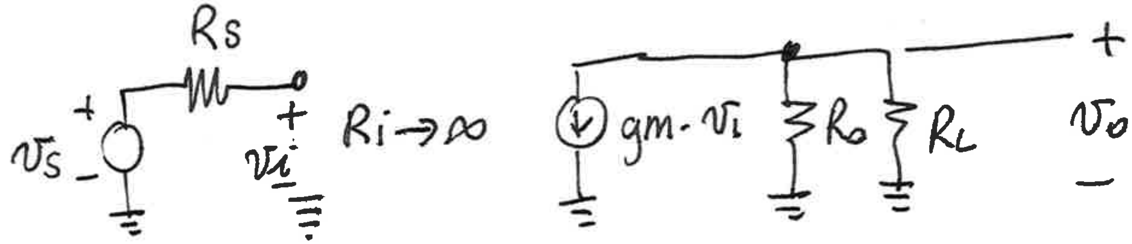
$$v_o = -\, g_m \cdot v_i \cdot R = -\, g_m \cdot v_i \, \frac{R_o R_L}{R_o + R_L}$$

$$A_v = \frac{v_o}{v_s} = -\, g_m \frac{R_o R_L}{R_o + R_L} \cdot \frac{R_i}{R_s + R_i}$$

for $R_o \to \infty$ $\quad A_v \simeq -\, g_m R_L \cdot \dfrac{R_i}{R_s + R_i}$



$R_o \to \infty$ means in practice $(R_o >> R_L)$



$$v_i = v_s \rightarrow \quad A_v = -g_m \frac{R_L R_o}{R_L + R_o} \cdot \frac{R_i}{R_s + R_i} \approx -g_m \frac{R_L R_o}{R_L + R_o}$$

$R_i \rightarrow \infty$

$R_i \rightarrow \infty$: in practice
$R_i \gg R_s$