Two Techniques - used by CAD programs

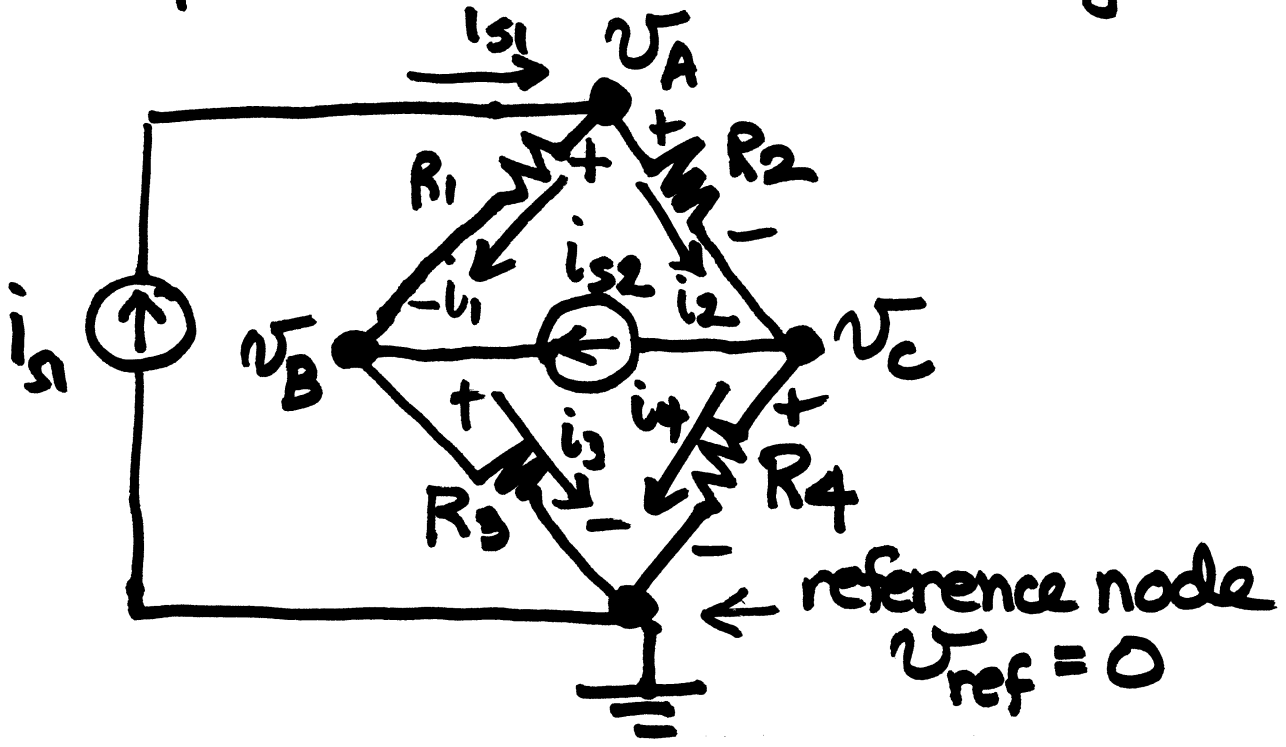
Multi Sim 7
Electronics Workbench

node voltage (KCL based)
mesh current (KVL based)

node voltage technique

1. Assign voltages to every node
   One of these is a reference node
   → ground reference, zero volts
2. write KCL equations for every node
3. write all currents in terms of node voltages
4. substitute currents into node KCL equations, put into standard form and solve

Example 3-1 Wheatstone bridge



Designed to measure very small changes in R or i

- strain gages
- variety of sensors

① label voltages at node

② write KCL equations at each node

KCL $\sum_{+in} i = 0$ @ A $\quad +i_{s1} - i_1 - i_2 = 0$

KCL $\sum_{+in} i = 0$ @ B $\quad +i_1 + i_{s2} - i_3 = 0$

KCL $\sum_{+in} i = 0$ @ C $\quad +i_2 - i_{s2} - i_4 = 0$

think 3 equations in 3 unknowns.

③ write currents in terms of node voltages

$$i_1 = \frac{v_A - v_B}{R_1}$$

$$i_2 = \frac{v_A - v_C}{R_2}$$

$$i_3 = \frac{v_B - 0}{R_3}$$

$$i_4 = \frac{v_C - 0}{R_4}$$

$i_{s1} - i_1 - i_2 = 0$

$i_{s1} - \frac{v_A - v_B}{R_1} - \frac{v_A - v_C}{R_2} = 0$

$\left(\frac{1}{R_1} + \frac{1}{R_2}\right) v_A - \frac{1}{R_1} v_B - \frac{1}{R_2} v_C = i_{s1}$ ①

use conductance $G = \frac{1}{R}$

$(G_1 + G_2) v_A - G_1 v_B - G_2 v_C = i_{s1}$

$+ i_1 + i_{s2} - i_3 = 0$

$\frac{v_A - v_B}{R_1} + i_{s2} - \frac{v_B}{R_3} = 0$

$\frac{1}{R_1} v_A - \left(\frac{1}{R_1} + \frac{1}{R_3}\right) v_B = -i_{s2}$ ②

$G_1 v_A - (G_1 + G_3) v_B = -i_{s2}$

$i_2 - i_{s2} - i_4 = 0$

$\frac{v_A - v_C}{R_2} - i_{s2} - \frac{v_C}{R_4} = 0$

$\frac{1}{R_2} v_A - \left(\frac{1}{R_2} + \frac{1}{R_4}\right) v_C = +i_{s2}$ ③

$G_2 v_A - (G_2 + G_4) v_C = +i_{s2}$

$$\left(\frac{1}{R_1}+\frac{1}{R_2}\right)v_A - \frac{1}{R_1}v_B - \frac{1}{R_2}v_C = i_{S1}$$

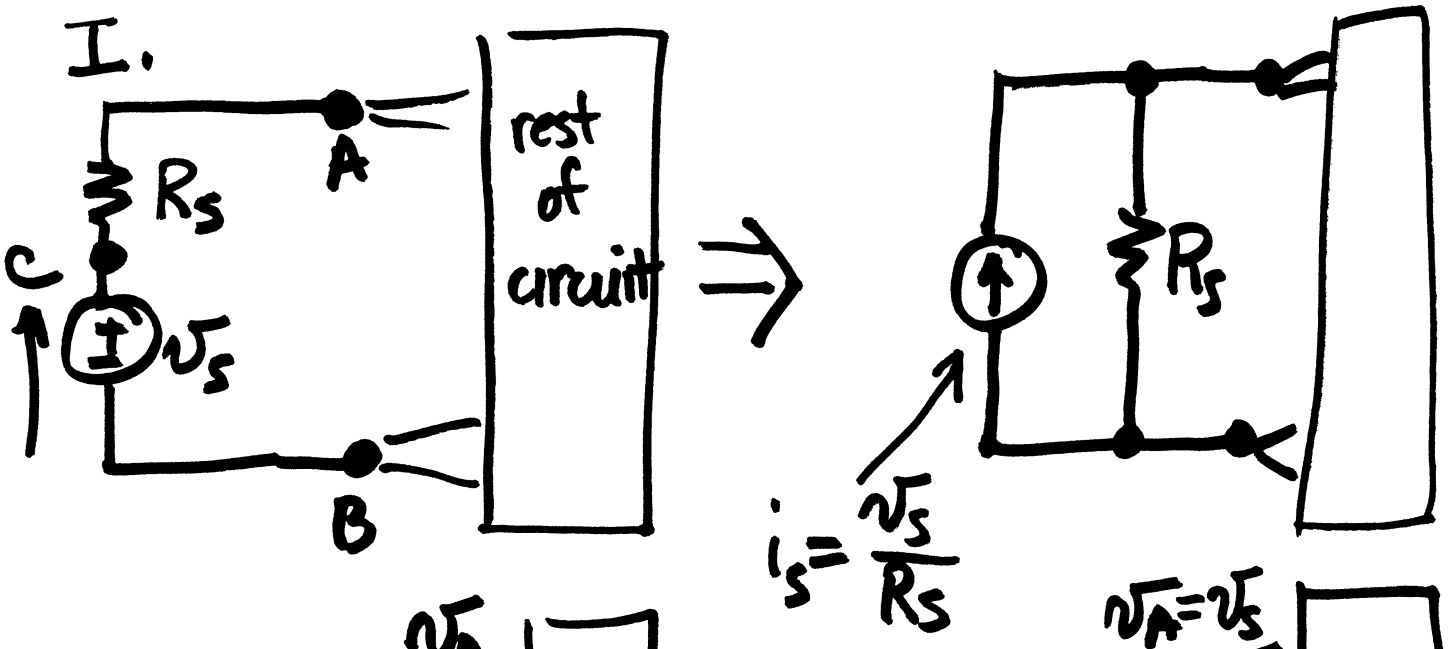
$$\frac{1}{R_1}v_A - \left(\frac{1}{R_1}+\frac{1}{R_3}\right)v_B = -i_{S2}$$

$$\frac{1}{R_2}v_A - \left(\frac{1}{R_2}+\frac{1}{R_4}\right)v_C = +i_{S2}$$

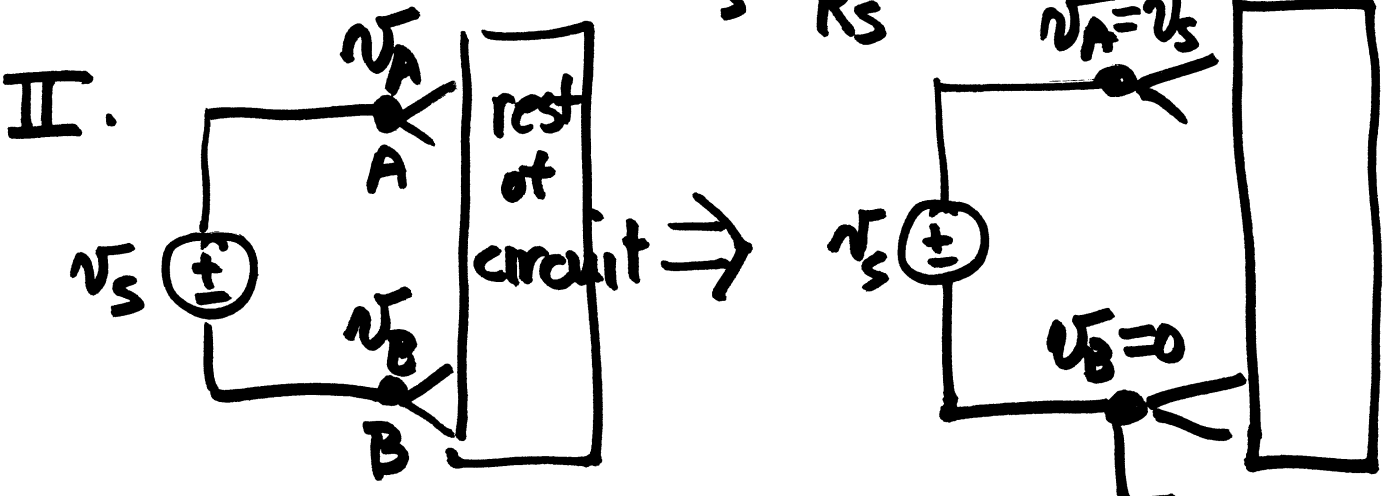
$$\begin{bmatrix} \frac{1}{R_1}+\frac{1}{R_2} & -\frac{1}{R_1} & -\frac{1}{R_2} \\ \frac{1}{R_1} & -\left(\frac{1}{R_1}+\frac{1}{R_3}\right) & 0 \\ \frac{1}{R_2} & 0 & -\left(\frac{1}{R_2}+\frac{1}{R_4}\right) \end{bmatrix} \begin{bmatrix} v_A \\ v_B \\ v_C \end{bmatrix} = \begin{bmatrix} i_{S1} \\ -i_{S2} \\ +i_{S2} \end{bmatrix}$$

Problems voltage sources are bad!

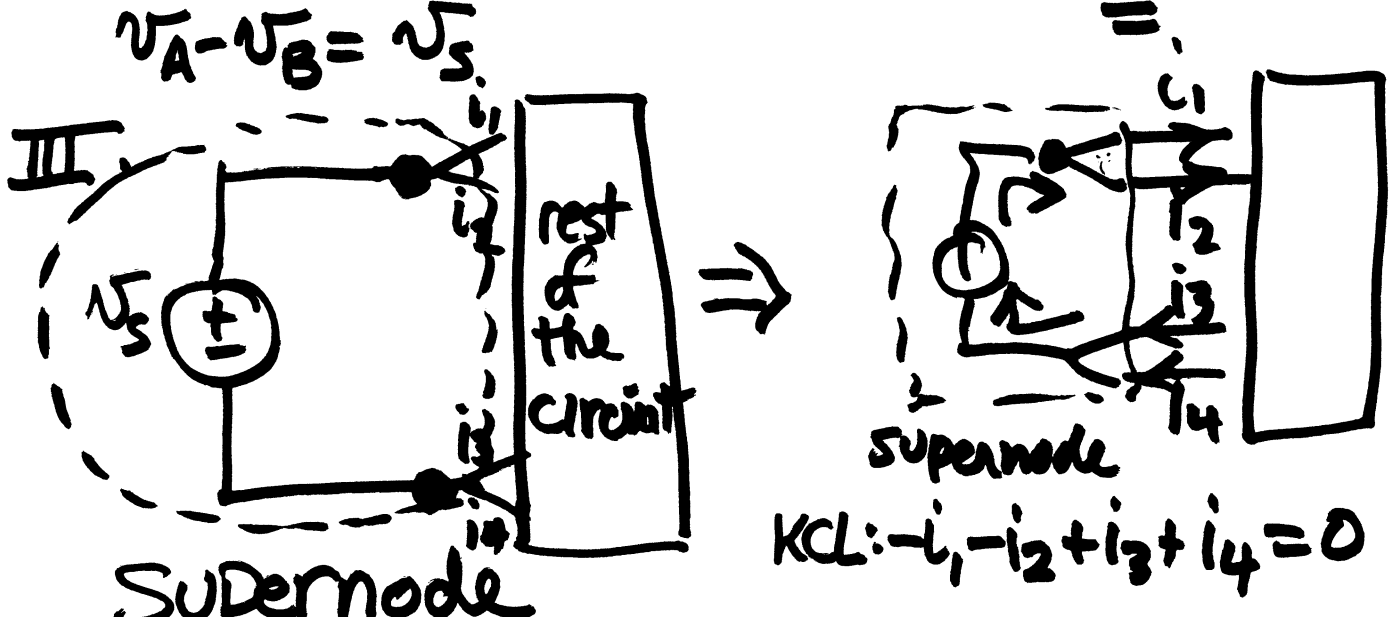
I.



II.



III.



Supernode