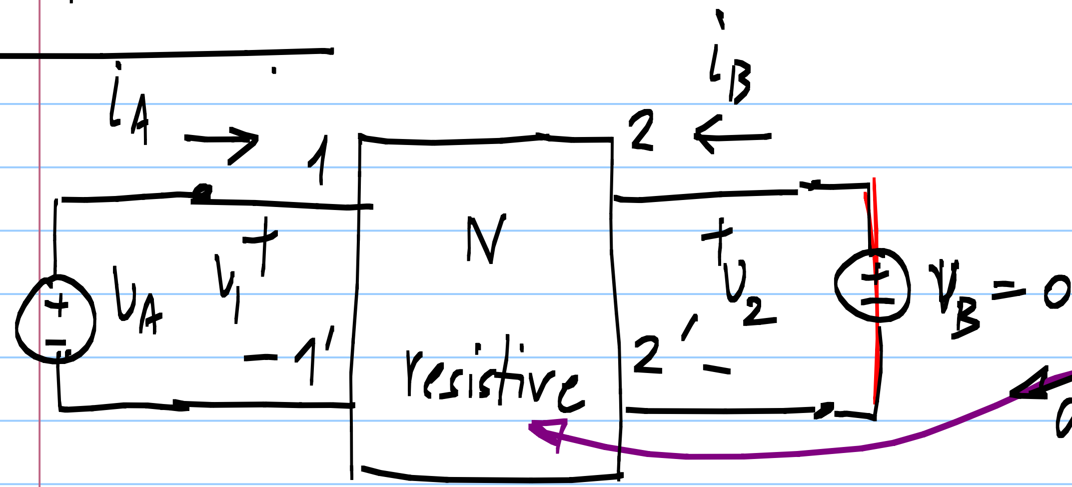
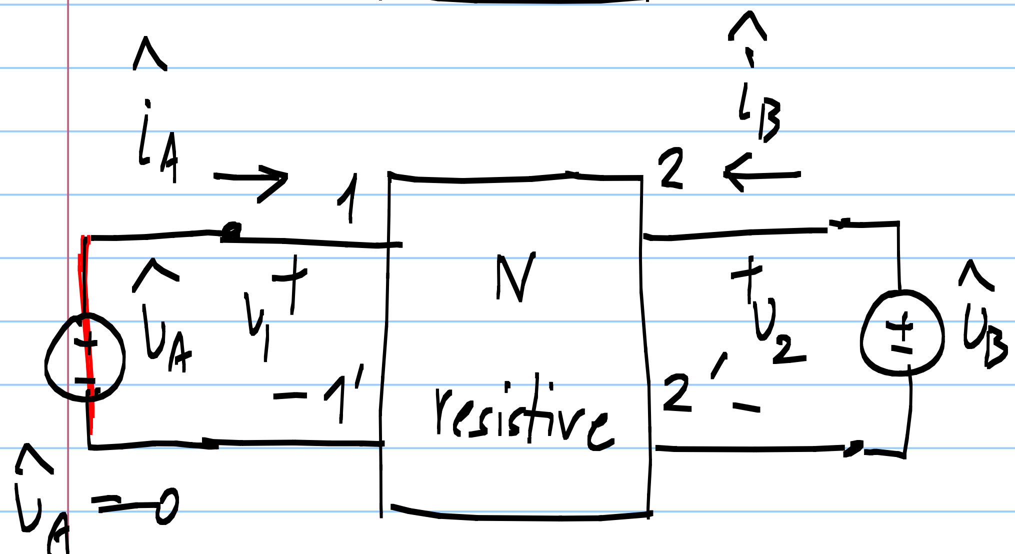
Lecture 12





By Tellegen's theorem

$$v_A(-\hat{i}_A) + \sum_k v_k \hat{i}_k = 0$$

all branches in N

$$\sum_k R_k \cdot i_k \cdot \hat{i}_k$$

$$\hat{v}_B(-i_B) + \sum_k \hat{v}_k i_k = 0$$

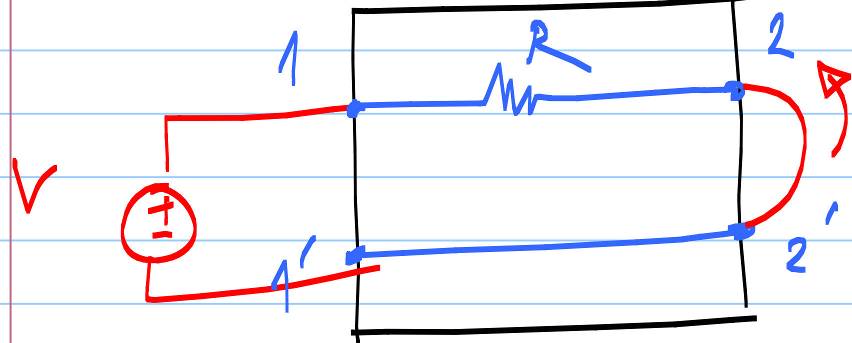
$$\sum_k R_k \cdot \hat{i}_k \cdot i_k$$

$$v_A(-\hat{i}_A)$$

$$= \hat{v}_B(-i_B)$$

$$\frac{i_B}{v_A} = \frac{\hat{i}_A}{\hat{v}_B}$$

"Reciprocal" network



$$\sum v_k \hat{i}_k$$

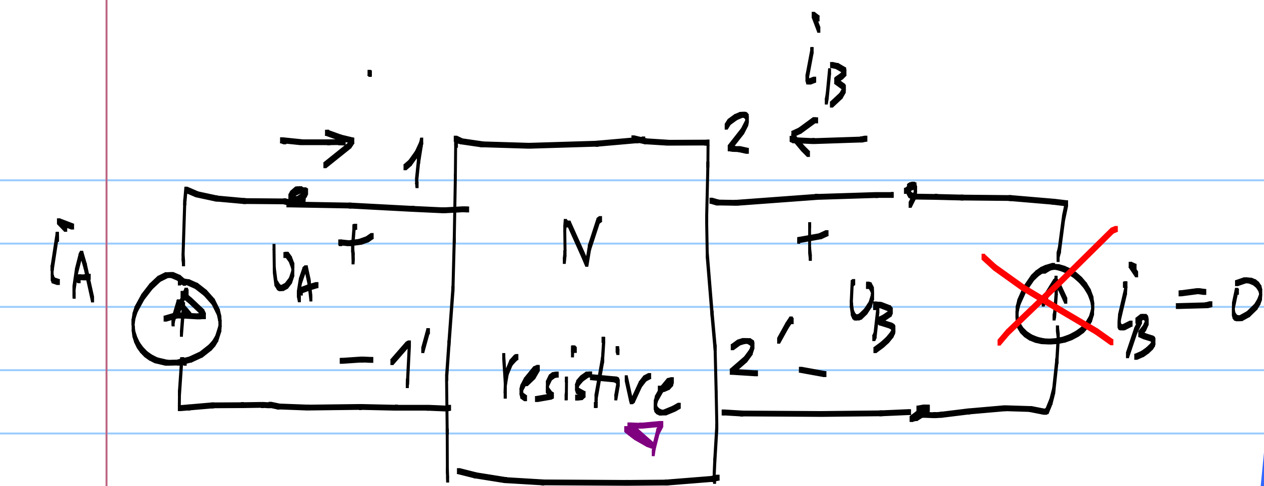
Capacitor : $v_k \cdot \hat{i}_k$

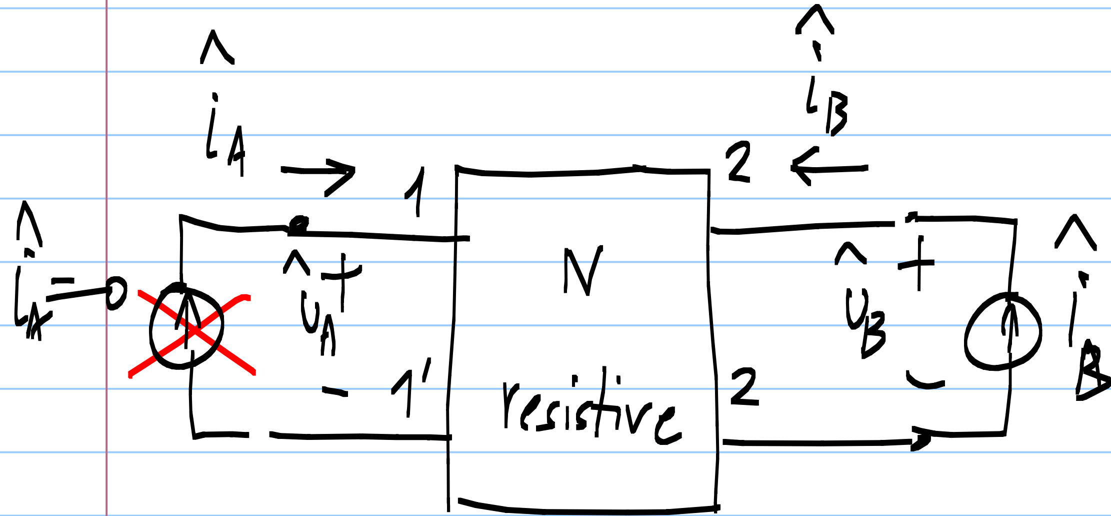
$C_k \cdot v_k \cdot \dot{\hat{v}}_k$

$$\sum \hat{v}_k i_k$$

$\neq$

Capacitor : $C_k \cdot \dot{v}_k \cdot \hat{v}_k$





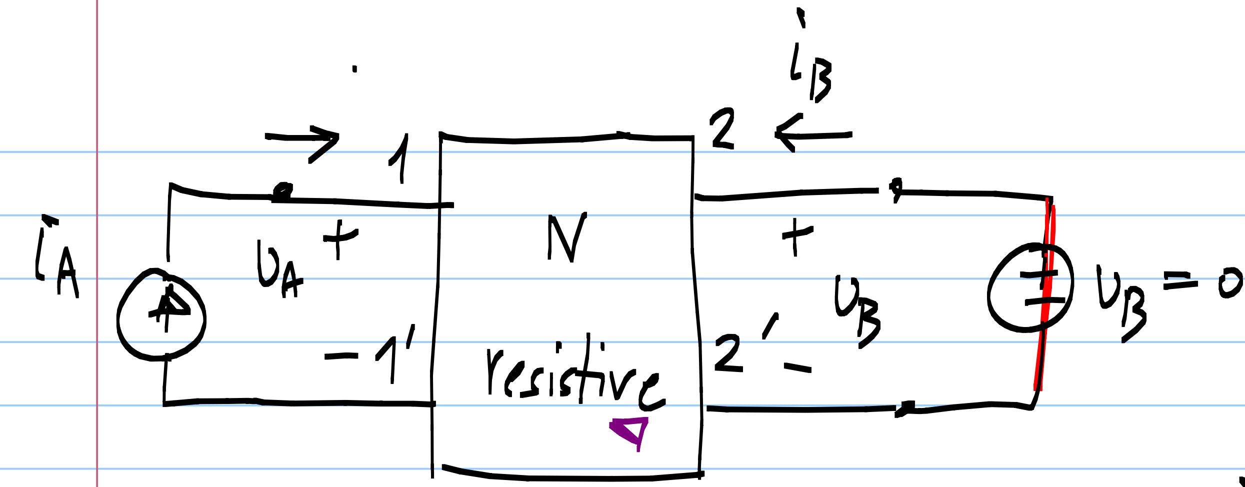
$$\boxed{i_A(-\hat{u}_A) = \hat{i}_B(-u_B)}$$

$$i_A(-\hat{u}_A) + \sum_k i_k \cdot \hat{u}_k = 0$$

$$\sum_k i_k \hat{u}_k = \sum_k R_k i_k \hat{i}_k = \sum_k \hat{i}_k u_k$$

$$\hat{i}_B(-u_B) + \sum_k \hat{i}_k u_k = 0$$

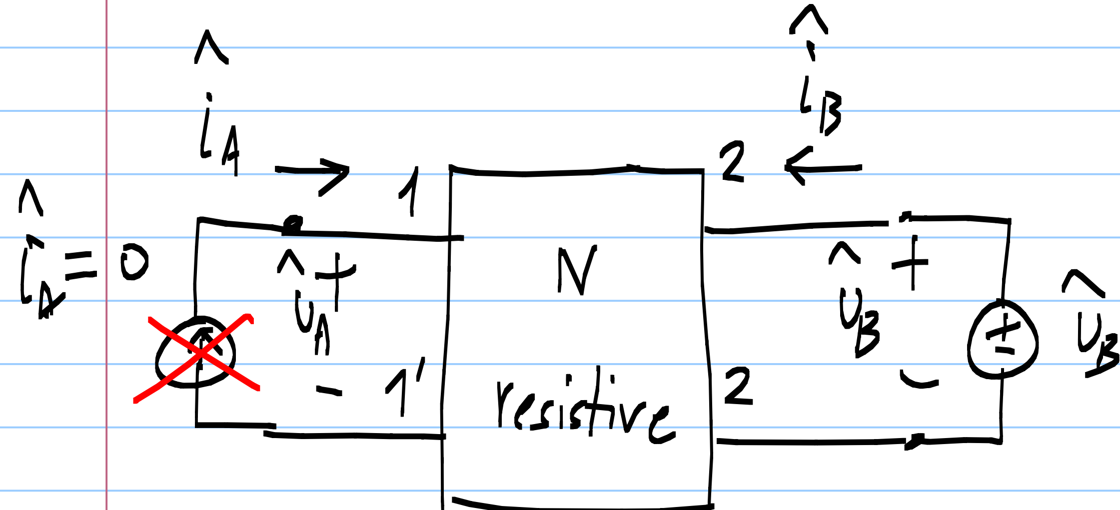
$$\frac{u_B}{i_A} = \frac{\hat{u}_A}{\hat{i}_B}$$



$$i_A(-\hat{v}_A) + \cancel{\sum_k i_k \cdot \hat{v}_k}$$

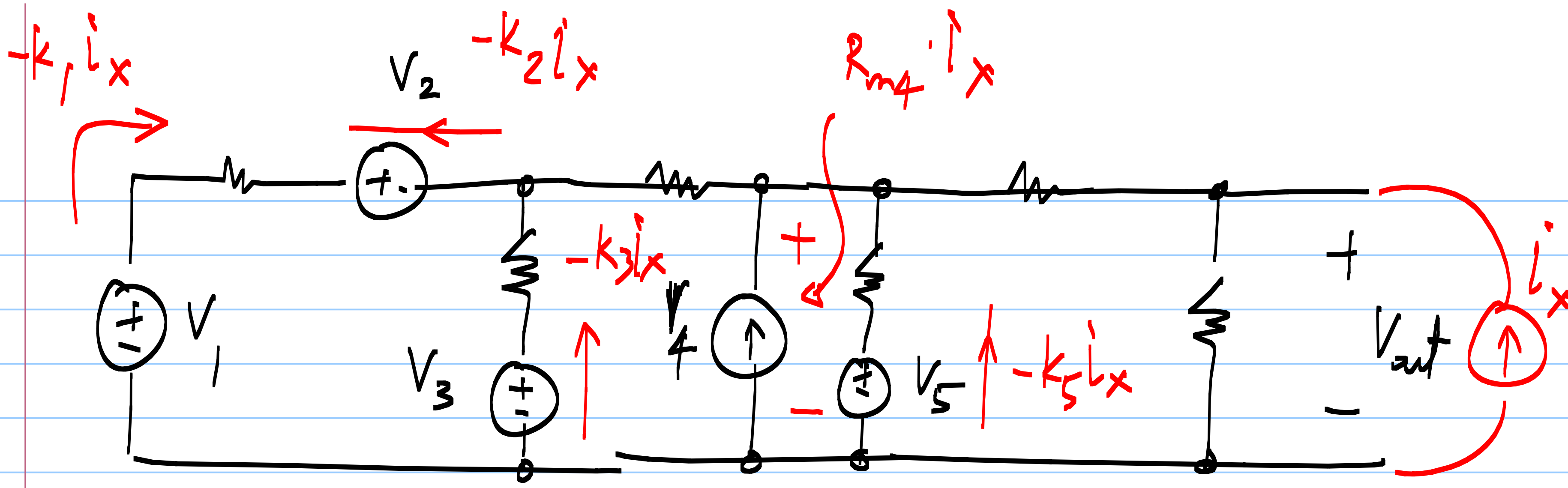
$$+\, i_B(-\hat{v}_B) = 0$$

$$i_A(-\hat{v}_A) + i_B(-\hat{v}_B) = 0$$

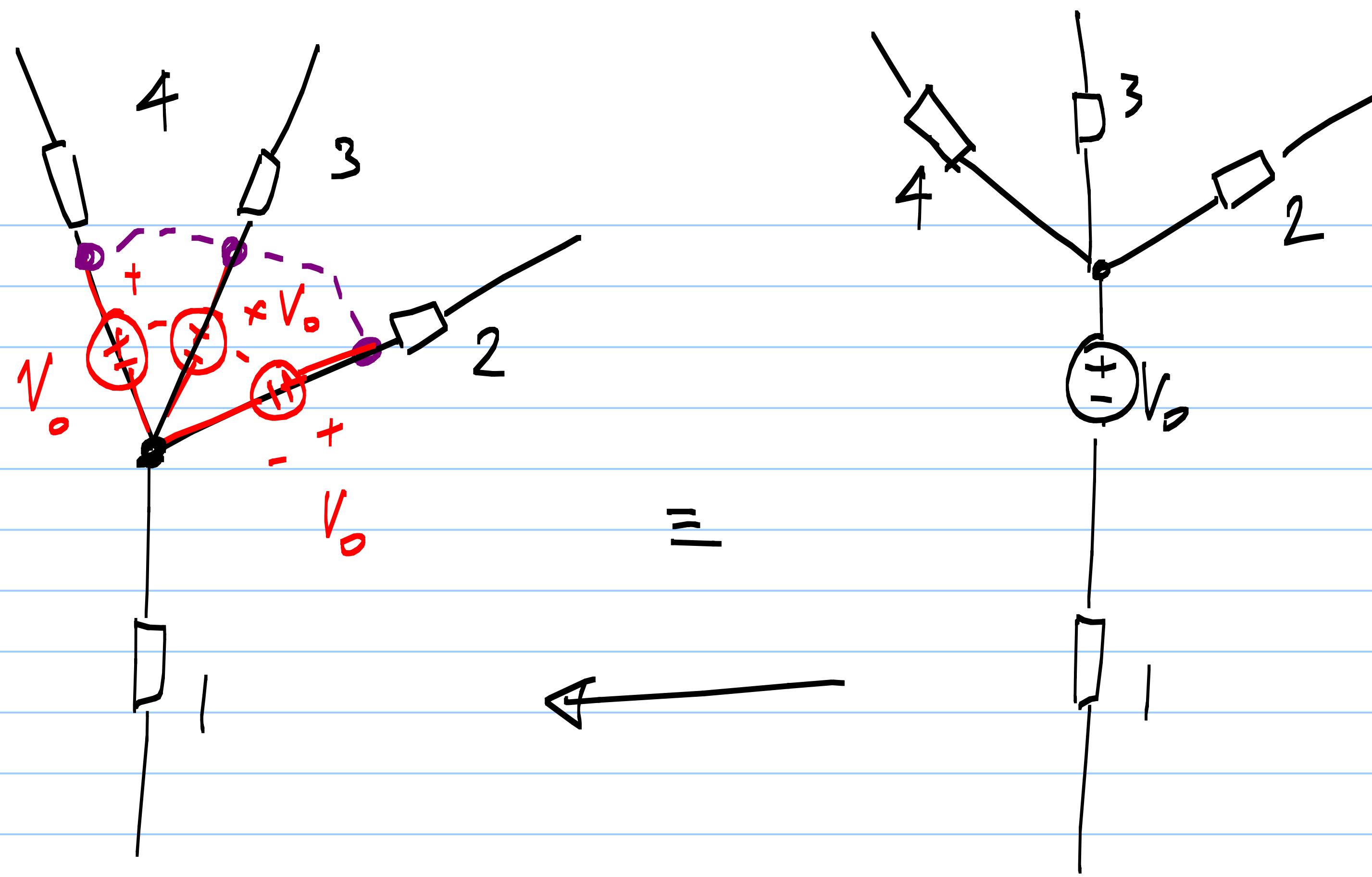


$$\cancel{\sum_k \hat{i}_k \cdot v_k = 0}$$

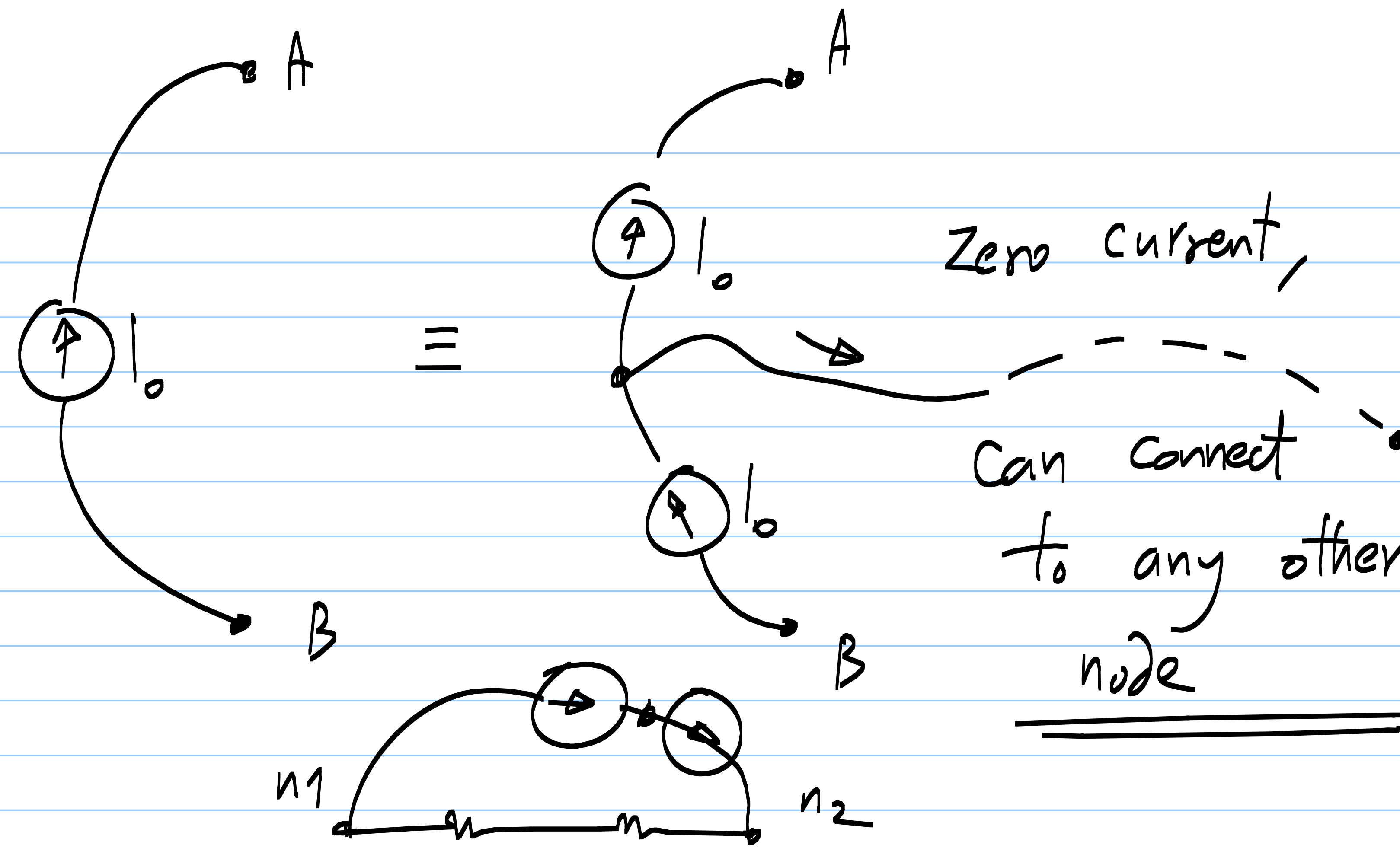
$$\frac{i_B}{i_A} = -\frac{\hat{v}_A}{\hat{v}_B}$$



$$V_{out} = k_1 V_1 + k_2 V_2 + k_3 V_3 + R_{m4} \cdot I_4 + k_5 V_5$$



node with many branches.



Zero current, Can connect to any other node