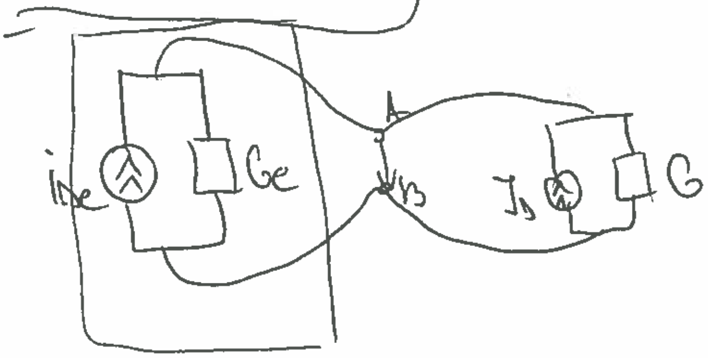
2) Current generator (Norton)

Any linear active dipole has an equivalent current generator with respect to its access terminals; this real current generator has the value of the current equal to the intensity of the short circuit current established if the access terminals will be short-circuited and in ∥ with an equivalent conductance corresp to the total conductance calculated with respect to the same terminals for the pasivised circuit.

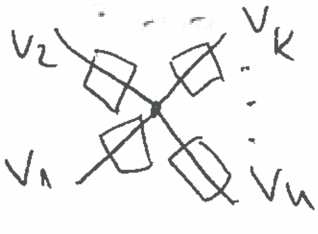
current circ → open circ
voltage circ → short circ.

$$U_{AB} = \frac{I_{se} + i_s}{G_e + G}$$



Millman Th refers to a star connection of n passive branches charact. by $R_1 \dots R_n$ and the electric potential of the terminals $V_1 \to V_n$.

$$V_0 = \frac{\sum V_k G_k}{\sum G_k}$$



Voltage divider

SERIE

$$\boxed{U_{R_k} = \frac{R_k}{\sum R_k} \cdot U}$$

$$U_{R_i} = R_i \cdot i = \frac{R_i \cdot U}{R_{eq}} = \frac{R_i}{\sum R_k} \cdot U$$

$$i = \frac{U}{R_{eq}}$$

$$\Rightarrow U_{R_k} = \frac{R_k}{\sum R_k} \cdot U$$

PARALEL.

$$\boxed{R_{eq} = \frac{1}{\sum \frac{1}{R_k}}}$$

$$\left(\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \dots + \frac{1}{R_n} \right)$$

Current divider

$$\boxed{i_k = i \cdot \frac{1}{R_k \cdot \sum \frac{1}{R_k}}}$$

$$i_k = \frac{u}{R_1} = \frac{i \cdot R_{eq}}{R_1} = i \cdot \frac{R_{eq}}{R_1} \qquad R_{eq} \to \frac{1}{\sum \frac{1}{R_k}}$$

$$= i \cdot \frac{1}{R_k \cdot \sum \frac{1}{R_k}}$$

Equivalent transformations

1) $R = \frac{1}{G}$ $\qquad G = \frac{1}{R}$

$E = i_s \cdot R$ $\iff$

$i_s = \frac{E}{R}$

2) R $\quad E$

i_s $\iff$ $R_e = R$ $\quad E_e = E + R i_s$

G

$i_{eq} = i_s + \frac{E}{R}$

$E_e = E - R i_s$

$E_e = R i_s - E$

serie in serie

3) a)

$R_1 \quad E_1 \quad R_2 \quad E_2 \quad \dots \quad R_n \quad E_n$

$R_e = \sum R_K$

$E_E = \sum E_K$

par. in serie

b) $G_1 \quad G_2 \quad G_3$

$i_{s1} \quad i_{s2} \quad i_{sn}$

Ge

i_{se}

$$i_{se} = \frac{R_K \cdot \sum i_{sK}}{\sum R_K}$$

$$Ge = \frac{1}{\sum \frac{1}{G}}$$

Loop Current Method

New imaginary unknown quantities = $\boxed{\text{loop currents}}$

$$\boxed{\sum_{g=1}^{B-N+1} R_{ng}\, i'_g = E'_n}\ ,\quad n=\overline{1,L}$$

a) $n=g \Rightarrow R_{11}, R_{22}\ldots$ = total resistance of the resp. loop calculated as sum of the resistances on the branches of that loop.

b) $n\neq g \rightarrow R_{12}, R_{13}\ldots$ etc = mutual resist of the 2 loops,
"+" if the loop currents have the same orientation through the common branch
"−" diff orientation

i'_g = unknown quantities
E'_n = total voltage of the loop; sum of all voltage sources from the branches of the resp loop.
"+" sources with the same orientation of the loop current
– find i'_g, then $i_1, i_2, \ldots$ as sum of i'_g (+ for the same or

Restriction
If the circuit contains one / more current sources, then the loops should be chosen so that the source not to be part of 2 loops simultaneously. ⇒ We identify the $i'g$ from that loop as $\underline{i'g = is}$.

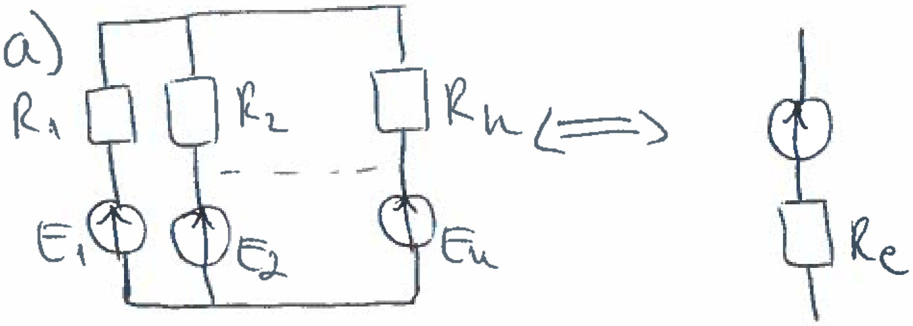
Node Potential Method

new set of unk quantities: node potential, assoc to the n nodes of the circuit as it follows: one of them is considered to be the reference node of potential 0, and the rest:

$V_N = 0$

$$\boxed{\sum_{j=1}^{N-1} G_{ij} V_j = i_{sci}}\qquad i=\overline{1,N-1}$$

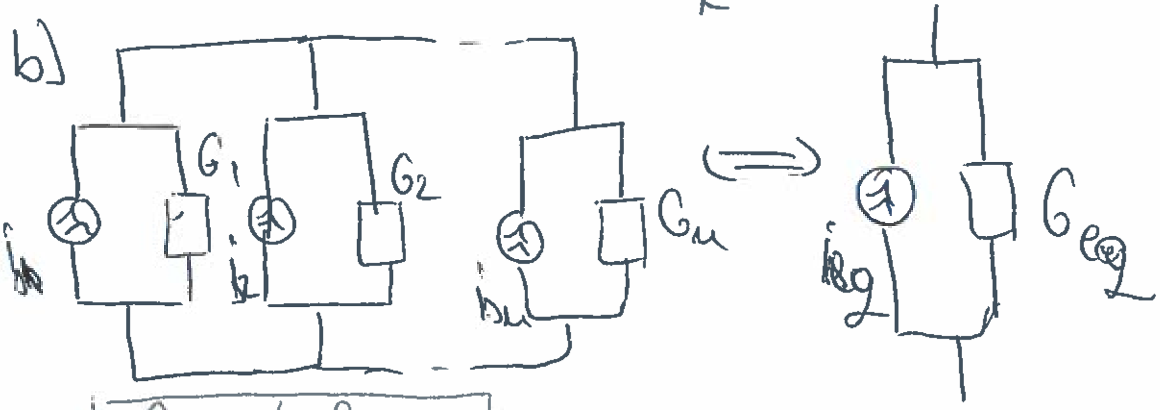
4) a)



serie în ∥

$$E_e = \frac{\sum E_k \cdot G_k}{\sum G_k} \qquad R_e = \frac{1}{\sum G_k}$$

b)



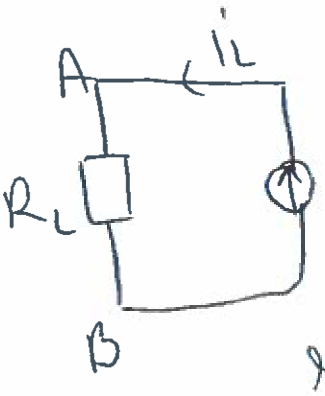
∥ în ∥

$$\boxed{\begin{aligned} G_e &= \sum G_k \\ i_{se} &= \sum i_{sk} \end{aligned}}$$

s s ~ p.p.

s.p ~ p.s.

Max power transfer



$$P = I_L^2 R_L = \frac{E^2 R_L}{(R_i+R_L)^2}$$

To find the max power, differentiate the above expression with respect to resistance R_L and equate to 0.

$$\frac{dP}{dR_L} = 0 \Rightarrow R_L = R_i$$

$\boxed{\text{Kirchhoff 1}}$ (node)

States that the algebrical sum of all the currents converging one node of an electric circuit is 0.

$\boxed{\sum_{K=1}^{N} I_K = 0}$ → the consequence of <u>electric charge conservation</u> applied on a closed surface

$\boxed{\text{Kirchhoff 2}}$ (loop)

The algebrical sum of the voltage drops on all the branches of a <u>loop</u> within an electric circuit is 0.

$\boxed{\sum_{K=1}^{N} u_K = 0}$ → consequence of the law of electric conduction, also of <u>Faraday's Law of conduction</u> (electromotive force along a closed path under steady conditions)

In case there are also current sources on the branches, <u>KII</u> will also contain the voltage drop on it.

Power conservation

The total electrical power generated by all voltage / current sources of the circuit is equal to the total electric power received by the receptors.

$\boxed{P_{gen} = \sum(\underbrace{E_K \cdot I_K}_{\text{voltage s.}} + \underbrace{U_{sc} \cdot I_{sc}}_{\text{current source}})}$ $\boxed{P_{gen} = P_{consumed}}$

The total power exchanged in a closed ideal circuit is 0

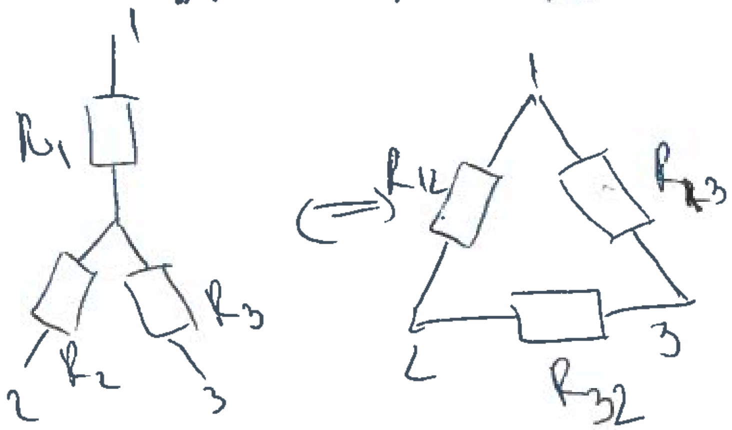
$\boxed{\text{Vashy I}}$

If we add (in all the branches connected to a node and in series with the elements on both branches) voltage sources of the same value and of the same orientation with resp. to the node, then the distribution of the currents / voltages on all the bipolar elem of the circuit will not be modified.

Vashy II)

If we add (in parallel with all the branches that are part of the same loop) current sources of the same value and with the same orientation related to an arbitrary one chosen, then the distribution of the current on all the bipolar elements of the circuit will not be modified.

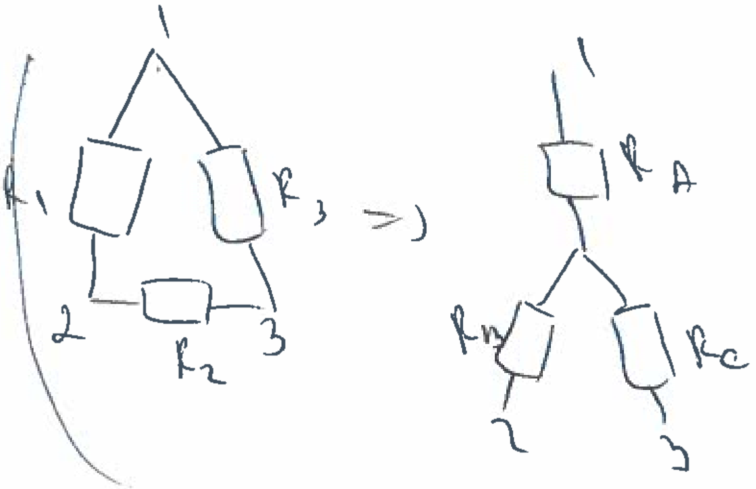
★ - Δ / Δ - ★



$$R_1 = \frac{R_{12} \cdot R_{13}}{R_{12} + R_{13} + R_{32}}$$

$$R_2 = \frac{R_{12} \cdot R_{23}}{R_{12} + R_{23} + R_{13}}$$

$$R_3 = \frac{R_{13} \cdot R_{32}}{R_{13} + R_{32} + R_{12}}$$



$$R_A = \frac{R_1 R_3}{R_1 + R_2 + R_3}$$

$$R_B = \frac{R_2 + R_1}{R_1 + R_2 + R_3}$$

$$R_C = \frac{R_3 \cdot R_2}{R_1 + R_2 + R_3}$$

Eq. generators

① Voltage generator (Thevenin)

Any linear active bipolar circuit can be replaced with an equivalent one with respect to the terminals, containing a voltage source ~~that~~ with the voltage equal to the ~~real~~ open-circuit voltage in series with its internal resistance.

$$\boxed{i = \frac{E_e \pm E}{R_e + R}}$$

$i=j \Rightarrow G_{11}, G_{22}, \ldots =$ the total conductance of the resp node calculated as sum of cond of all branches connected to that node.

$i \neq j \rightarrow G_{12}, G_{23} \ldots =$ sum of the conductances of the branches between 2 nodes and the sgn is „–".

– <u>free term</u> = total short circuit current of the resp node calculated as sum of all short circuit current of the branches connected to that node.

+ enter, – exit

Short cc. of a branch = the current established in that branch if we extract it from the circuit and we short-circ its terminals.

$G_{ij} \rightarrow i=j, \geq 0$
$\quad \hookrightarrow i \neq j, < 0.$

– det the unk potentials $\Rightarrow$ the currents on the branches + voltage drops on the current sources with Ohm's Law on each branch.

<u>Restriction</u>: If a branch contains only ideal voltage source $\Rightarrow$ the reference node will be one of the terminals of that branch. For the other terminal we write Ohm's Law on the branch instead of the specific equation.