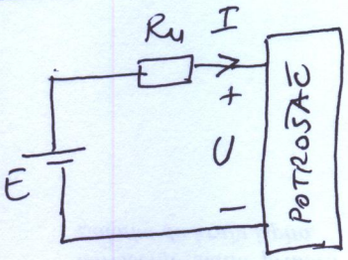
Jednosmerne struje

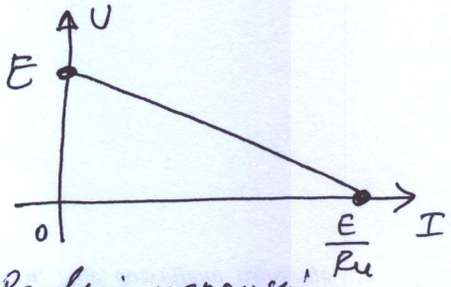
Primer 1



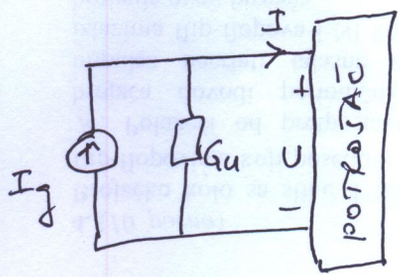
$$U = -R_u I + E$$

za $I = 0 \Rightarrow U = E$

za $I = \frac{E}{R_u} \Rightarrow U = 0$



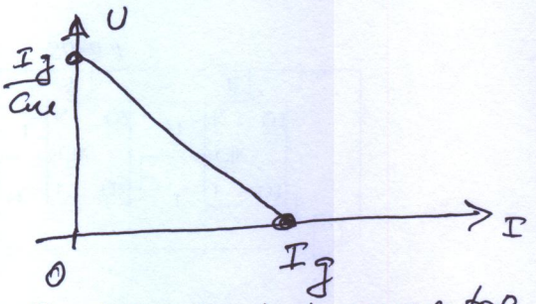
Realni naponski generator



$$I = I_g - G_u U$$

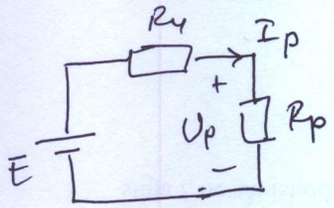
za $U = 0 \Rightarrow I = I_g$

za $U = \frac{I_g}{G_u} \Rightarrow I = 0$



Realni strujni generator

Primer 2

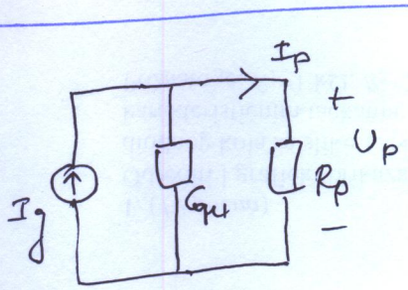


$$P_{Rp} = U_p I_p = R_p I_p^2 = \frac{U_p^2}{R_p} \Leftrightarrow P_{E,R_u} = E I_p - R_u I_p^2$$

$$I_p R_p + I_p R_u - E = 0$$

$$I_p = \frac{E}{R_u + R_p}, \quad U_p = \frac{R_p E}{R_u + R_p} \Rightarrow P_{Rp} = \frac{R_p E^2}{(R_u + R_p)^2}$$

$$P_{E,R_u} = \frac{E^2}{R_u + R_p} - \frac{R_u E^2}{(R_u + R_p)^2}$$



$$P_{Rp} = U_p I_p = R_p I_p^2 = \frac{U_p^2}{R_p} = U_p (I_g - G_u U_p)$$

$$\left(I_p = I_g - U_p G_u\right)$$

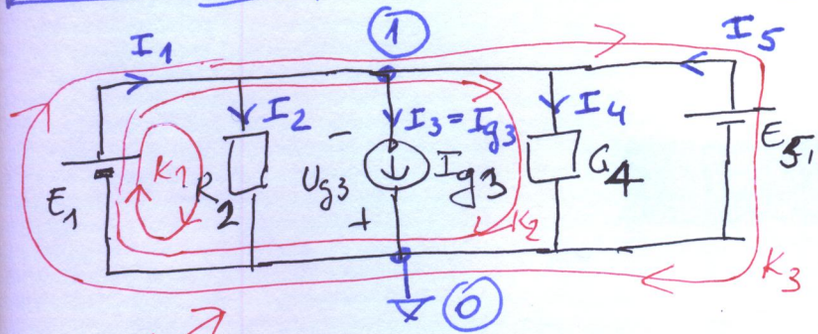
$$P_{Rp} = U_p I_g - G_u U_p^2$$

$$\Leftrightarrow P_{I_g, G_u}$$

$$U_p = I_g / \left(G_u + \frac{1}{R_p}\right)$$

$$P_{Rp} = \frac{U_p^2}{R_p} = \frac{I_g^2}{R_p \left(G_u + \frac{1}{R_p}\right)^2}$$

Primer (3)



POGODNO JE DA KONTURE PROLAZE KROZ IDEALNI NAPONSKI generator E jer SVAKA JEDNAČINA IMA SAMO JEDNU NEPOZNATU STRUJU PA SE sistem lako rešava!
(Ne mora ovako, ali će onda biti više pisanja....

Nema 5 NEPOZNATIH jer je $I_3 = I_{g3}$!

$n_g = 5$, $n_č = 2$

Ikt: $n_č - 1 = 1$ jednačina

(1) $I_1 + I_5 = I_2 + I_{g3} + I_4$ (1)

IIkt: $n_K = n_g - (n_č - 1) - n_{Ig}$

$n_K = 5 - (1) - 1$

$n_K = 3$ KONTURE

(NE UZIMATI KONTURE KROZ I_{g3} ?)

K_3: $-E_1 + E_5 - R_{45} I_5 = 0$

$\Rightarrow \boxed{I_5 = \frac{E_5 - E_1}{R_{45}}}$ (2)

K_2: $-E_1 + \frac{I_4}{G_4} = 0$

$\Rightarrow \boxed{I_4 = G_4 E_1}$ (3)

K_1: $-E_1 + R_2 I_2 = 0$

$\boxed{I_2 = \frac{E_1}{R_2}}$ (4)

(1) zamenimo (2), (3) i (4):

$I_1 = I_2 + I_4 + I_{g3} - I_5$

$I_1 = \frac{E_1}{R_2} + G_4 E_1 + I_{g3} - \frac{E_5}{R_{45}} + \frac{E_1}{R_{45}}$

Potencijal: $V_0 = 0$. referentni čvor

$V_1 = U_{10} = E_1$

Snage: $P_{E1} = E_1 I_1 = \frac{E_1^2}{R_2} + G_4 E_1^2 + E_1 I_{g3} - \frac{E_1 E_5}{R_{45}} + \frac{E_1^2}{R_{45}} \gtrless 0$

GENERATOR SE MOGAO DA SE PONAŠA I KAO POTROŠAČ AKO JE E_5 MNOGO VEĆI OD E_1 ($E_5 \gg E_1$)

$P_{R2} = R_2 I_2^2 = \frac{E_1^2}{R_2}$

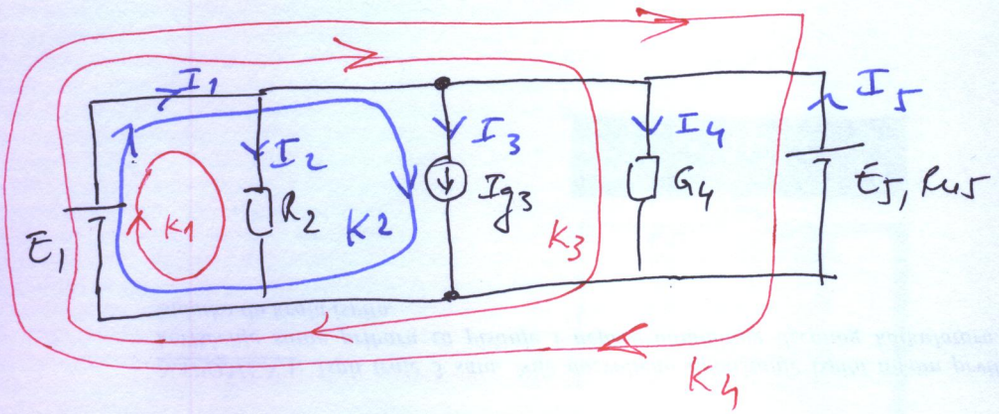
$P_{Ig3} = U_{g3} I_{g3} = -U_{10} I_{g3} = -E_1 I_{g3} < 0$ GENERATOR SE PONAŠA KAO POTROŠAČ!

$P_{G4} = \frac{1}{G_4} I_4^2 = \frac{G_4^2 E_1^2}{G_4} = G_4 E_1^2$

$P_{E5,R45} = U_{10} \cdot I_5 = E_1 \left(\frac{E_5 - E_1}{R_{45}} \right) = \frac{E_1 E_5}{R_{45}} - \frac{E_1^2}{R_{45}} \gtrless 0$

Generator se ponaša tako samo ako je $E_5 > E_1$ inače se ponaša kao potrošač!

Primer (4)



* $n_k = n_g - (n_č - 1) = 5 - 1 = 4$ konture
* Jedna kontura mora proći SAMA kroz I_{g3} u smeru I_{g3}.
  Ako je to k_2 tada je $I_{k2} = I_{g3}$.
* Ostale 3 konture se biraju tako da ne prolaze kroz I_{g3}
* Konture je najbolje birati tako da imaju što manje zajedničkih grana (otpornosti međusobnih)
  Ovde sve konture imaju zajednički samo E_1 i
  tada su sve međusobne otpornosti $\boxed{R_{ij} = 0}$?

Sistem bi bio 4x4:

$$K1: \quad R_{11} I_{k1} + R_{12} \cancel{I_{k2}}^{I_{g3}} + R_{13} I_{k3} + R_{14} I_{k4} = \sum_{k1} E$$

$$K2: \quad I_{k2} = I_{g3}$$

$$K3: \quad R_{31} I_{k1} + R_{32} \cancel{I_{k2}}^{I_{g3}} + R_{33} I_{k3} + R_{34} I_{k4} = \sum_{k3} E$$

$$K4: \quad R_{41} I_{k1} + R_{42} \cancel{I_{k2}}^{I_{g3}} + R_{43} I_{43} + R_{44} I_{k4} = \sum_{k4} E$$

$$K1: \quad R_2 I_{k1} = E_1 \Rightarrow I_{k1} = E_1/R_2$$

$$K2: \quad I_{k2} = I_{g3}$$

$$K3: \quad \left(\frac{1}{G_4}\right) I_{k3} = E_1 \Rightarrow I_{g3} = G_4 E_1$$

$$K4: \quad R_{u5} I_{k4} = E_1 - E_5 \Rightarrow I_{k4} = \frac{E_1 - E_5}{R_{u5}}$$

$$I_1 = I_{k1} + I_{k2} + I_{k3} + I_{k4}$$

$$I_1 = \frac{E_1}{R_2} + I_{g3} + G_4 E_1 + \frac{E_1 - E_5}{R_{u5}}$$

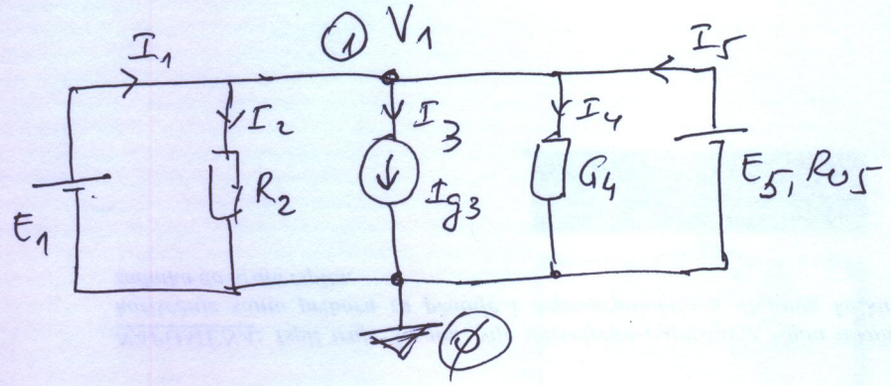
$$I_2 = I_{k1} = E_1/R_2$$

$$I_3 = I_{g3} = I_{k2}$$

$$I_4 = I_{k3} = G_4 E_1$$

$$I_5 = -I_{k4} = \frac{E_5 - E_1}{R_{u5}}$$

Primer 5



MNJ̄C / MPC̄

* $n_{\bar{c}} - 1 = 1$
* idealni E_1

$n_{\bar{c}} - 1 - n_E = \emptyset$

⇒ nema jednačine po MPC̄!

(1): $V_1 = E_1$

* Struje se nalaze na isti način kao je izvedena MPC̄:

$$V_1 = U_{10} = R_2 I_2 \Rightarrow I_2 = \frac{V_1}{R_2} = \frac{E_1}{R_2}$$

$I_3 = I_{g3}$ (ovo ne zavisi od metode)

$$V_1 = U_{10} = \frac{1}{G_4} \cdot I_4 \Rightarrow I_4 = G_4 V_1 = G_4 E_1$$

$$V_1 = U_{10} = E_5 - R_{45} I_5 \Rightarrow I_5 = \frac{E_5 - V_1}{R_{45}} = \frac{E_5 - E_1}{R_{45}}$$

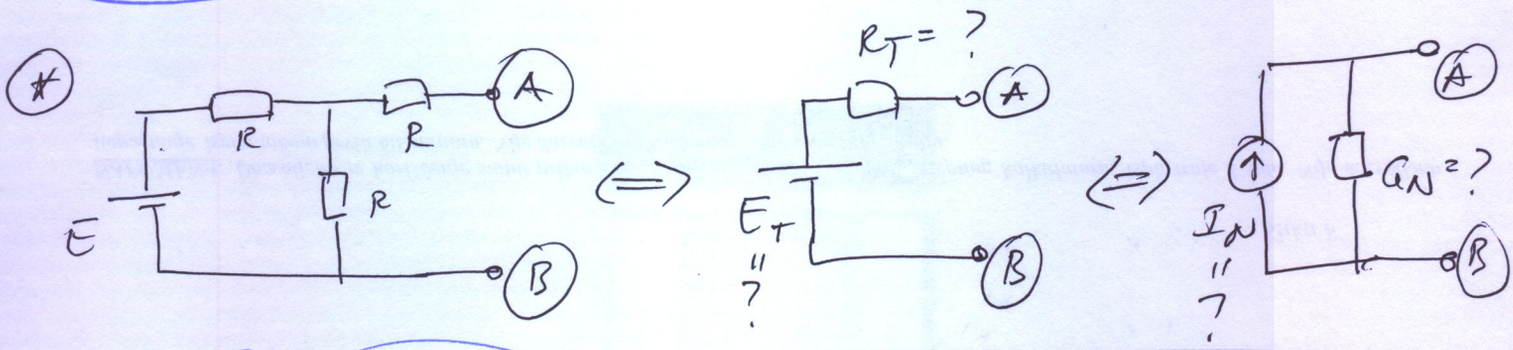
* Kako naći $I_1 = ???$ Kroz idealni E_1 ne može isto,

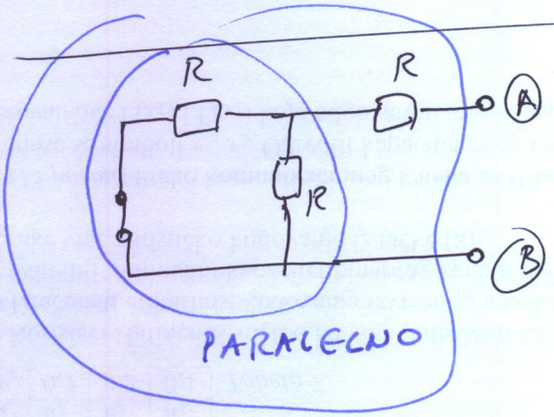
⇒ mora se koristiti I KZ

$$I_1 = I_2 + I_3 + I_4 - I_5$$

$$I_1 = \frac{E_1}{R_2} + I_{g3} + G_4 E_1 + \frac{E_1}{R_{45}} - \frac{E_5}{R_{45}}$$

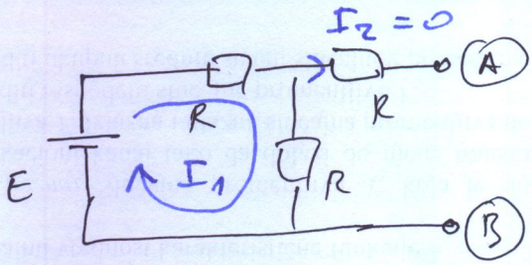
Primer 6





$$R_T = R_{AB} = R + \frac{R \cdot R}{R+R} = R + \frac{R}{2} = \frac{3}{2}R$$

$$G_N = \frac{1}{R_T} = \frac{1}{R_{AB}} = \frac{2}{3R}$$

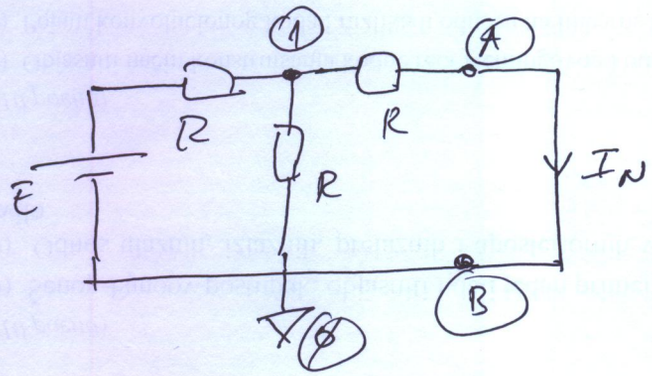


$$-E + RI_1 + RI_1 = 0$$

$$I_1 = E/2R$$

$$E_T = U_{AB0} = RI_1 - \cancel{RI_2}^{\,0}$$

$$\boxed{E_T = E/2}$$

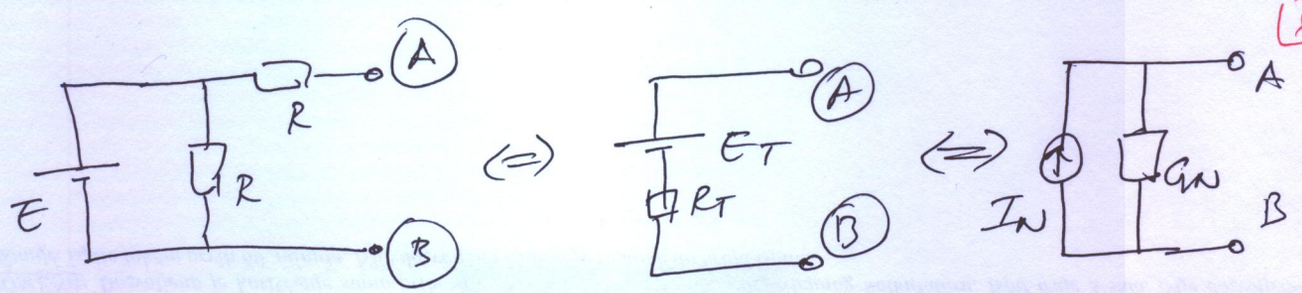


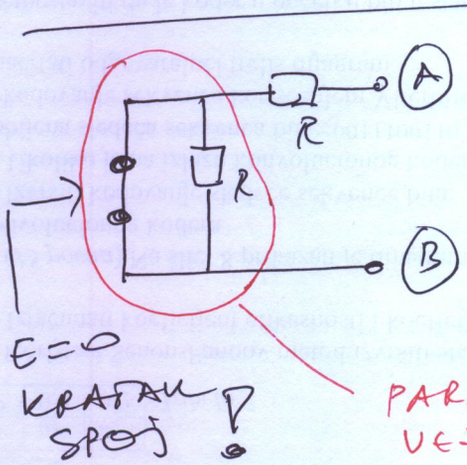
$$\left(\frac{1}{R} + \frac{1}{R} + \frac{1}{R}\right) V_1 = \frac{E}{R}$$

$$V_1 = \frac{E}{3}$$

$$\boxed{I_N = \frac{V_1}{R} = \frac{E}{3R}}$$

(*)



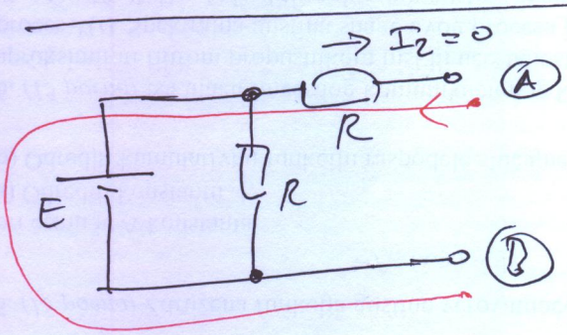


PARALELNA VEZA R i KS

$R_{ekv} = \frac{0 \cdot R}{0+R} = 0$!

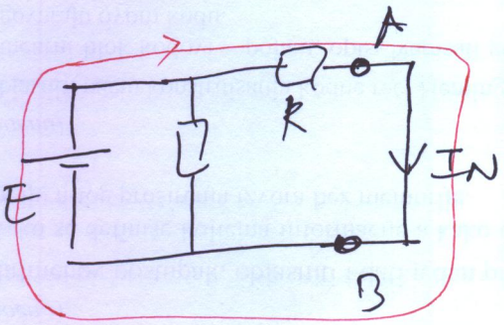
$R_{ekv} = R_T = R + \frac{0 \cdot R}{0+R} = R = R_T$

$G_N = \frac{1}{R}$



$E_T = U_{AB0} = -R \cdot I_2 + E = E$

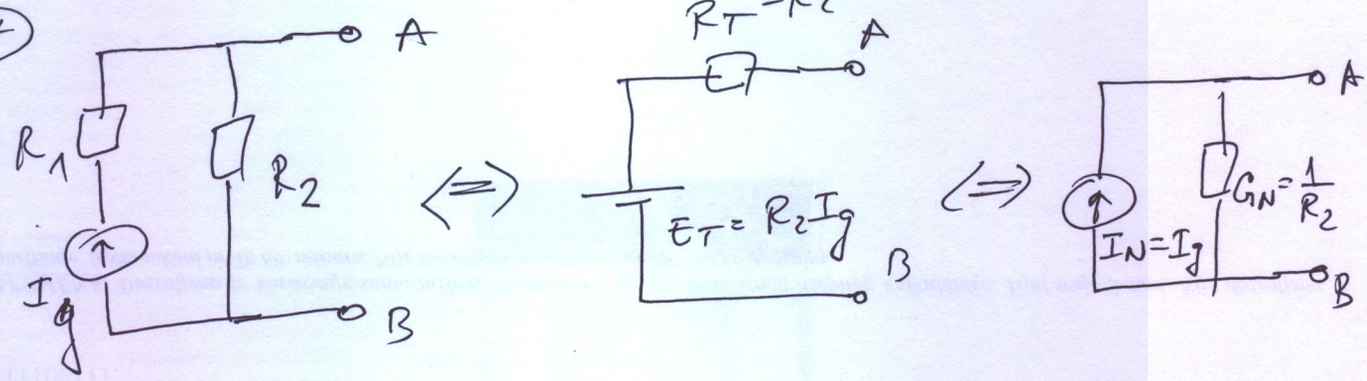
$E_T = E$

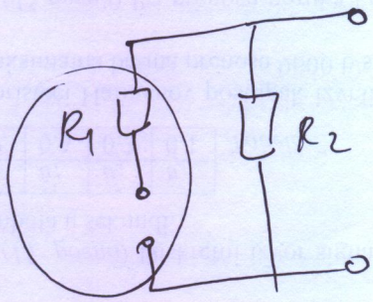


$-E + R I_N = 0$

$I_N = E/R$

(*)





$$\frac{1}{R_T} = \frac{1}{R_2} + \frac{1}{R_{ekw}} \Rightarrow \boxed{R_T = R_2}$$

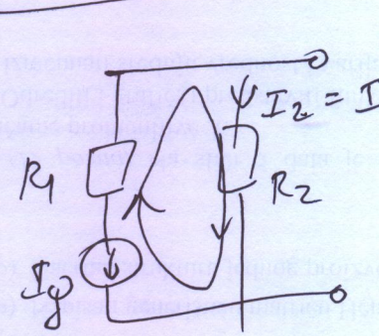
$$\boxed{G_N = \frac{1}{R_2}}$$

Rekwo

$R_{ekw} = R_1 + \infty = \infty$

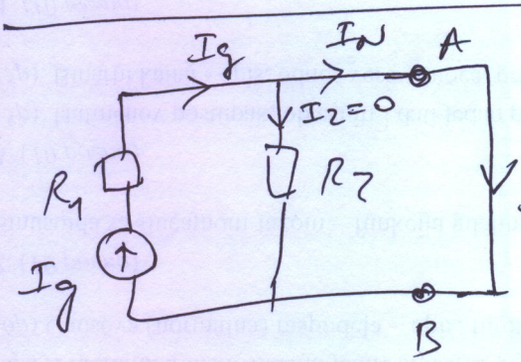
$\Rightarrow$ OV

$(G_{ekw} = 0)$



$$E_T = U_{AB0} = R_2 I_2 = R_2 I_g$$

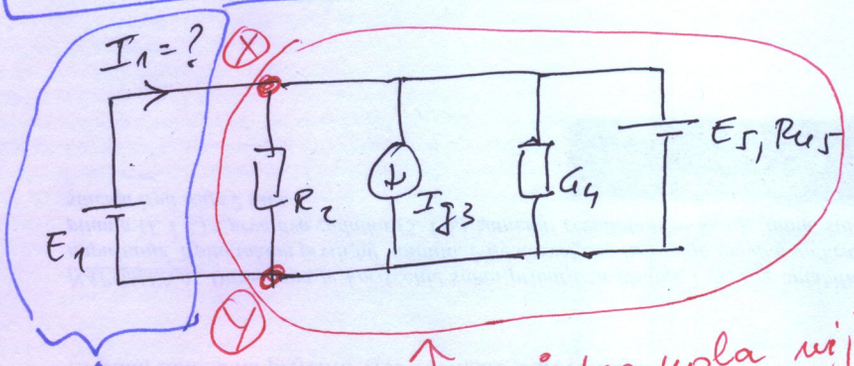
$$\boxed{E_T = R_2 I_g}$$



$$I_g = I_N + I_2 = I_N$$

$$\boxed{I_N = I_g}$$

Primer 7

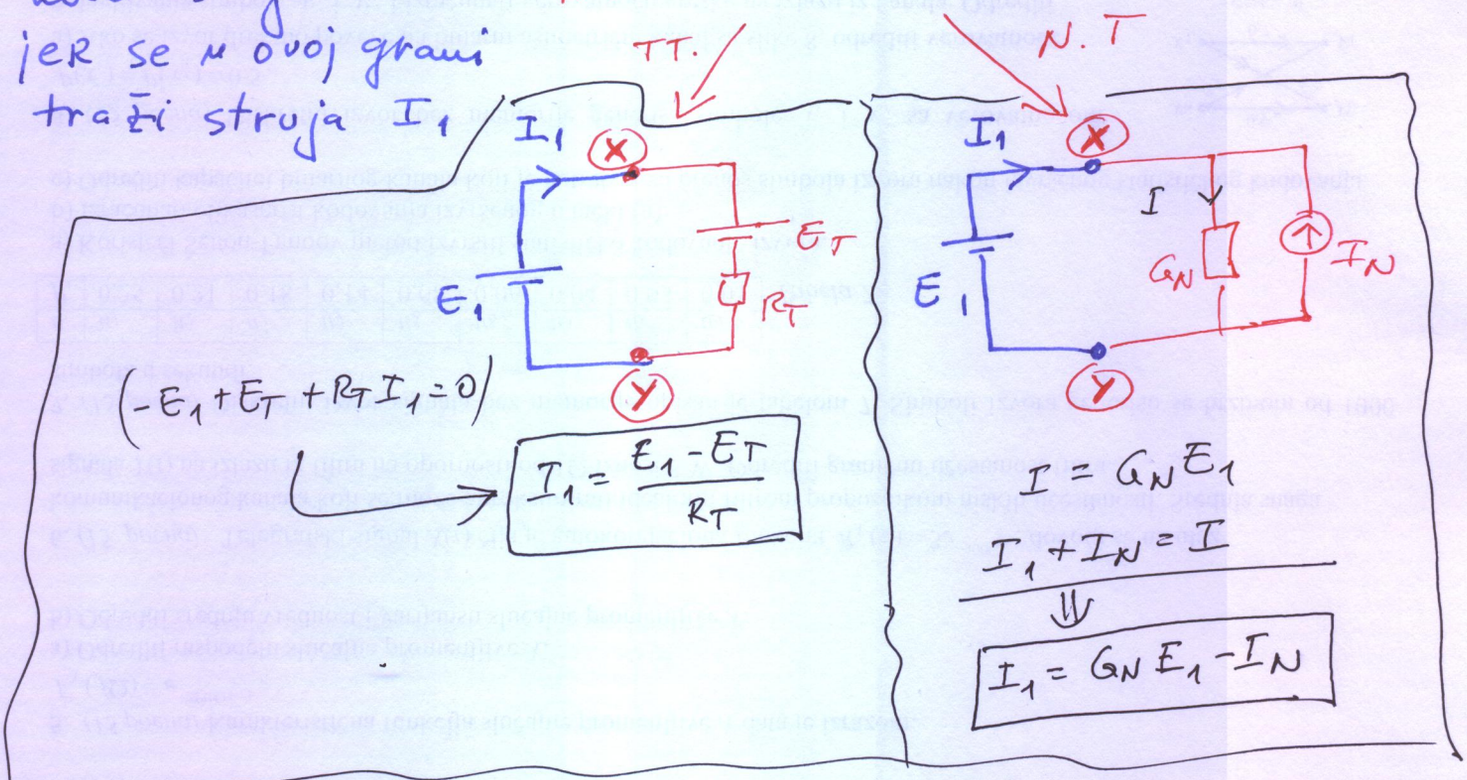


Primenom T.T. i N.T. naći I_1

↑ ovaj deo kola nije potrebno rešavati

⇒ može se zameniti Tevenenovim ili Nortonovim generatorom!

ovaj deo kola ostaje jer se u ovoj grani traži struja I_1



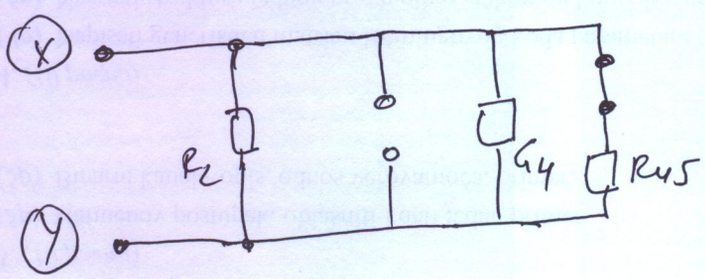
$$(-E_1 + E_T + R_T I_1 = 0)$$

$$I_1 = \frac{E_1 - E_T}{R_T}$$

$$I = G_N E_1$$

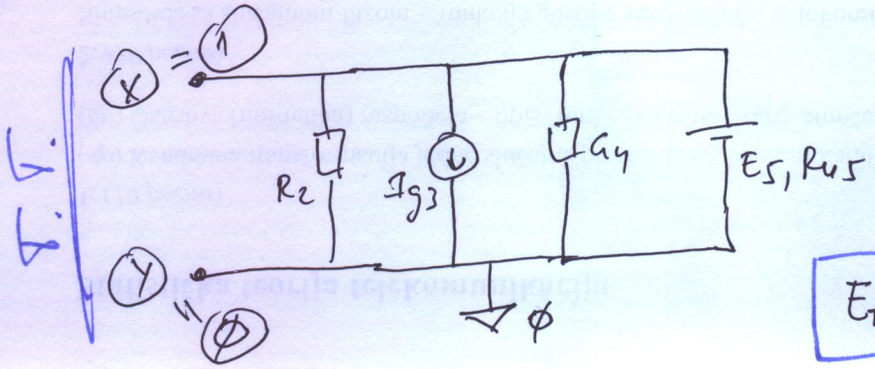
$$I_1 + I_N = I$$

$$I_1 = G_N E_1 - I_N$$



$$R_T = \frac{1}{\frac{1}{R_2} + G_4 + \frac{1}{R_{u5}}}$$

$$G_N = \frac{1}{R_2} + G_4 + \frac{1}{R_{u5}}$$



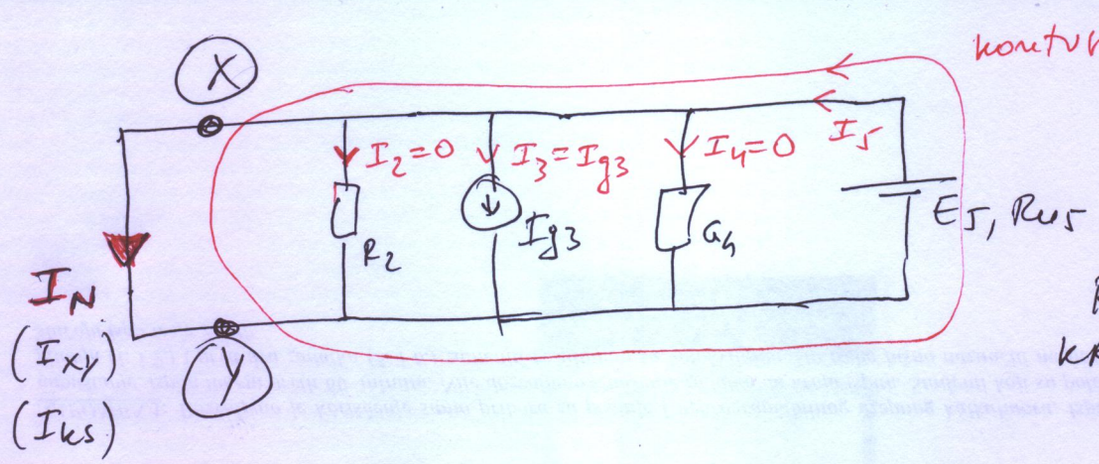
$E_T = U_{XY0} = V_1$ ← MPČ

$G_{11} V_1 = \sum_{①} I$

$$\left(\frac{1}{R_2} + G_4 + \frac{1}{R_{u5}}\right) V_1 = \frac{E_5}{R_{u5}} - I_{g3}$$

$$E_T = V_1 = \frac{E_5/R_{u5} - I_{g3}}{1/R_2 + G_4 + 1/R_{u5}}$$

N. T.



R_2 i G_4 su KRATKO spojeni

$U_{R2} = U_{G4} = 0$

$I_{R2} = I_4 = 0$

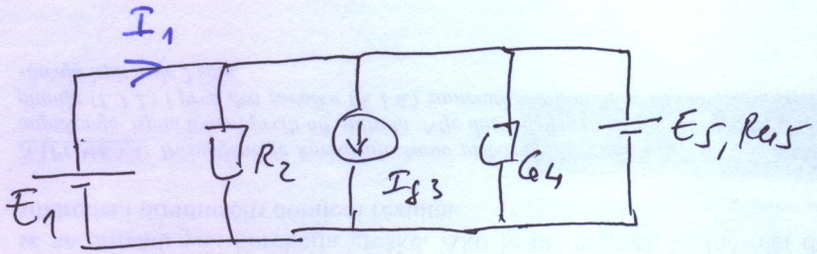
Kontura K: $-E_5 + R_{W5} I_5 = 0$

$I_5 = E_5 / R_{W5}$

ČVOR (X): $I_N + \overset{0}{\cancel{I_2}} + I_3 + \overset{0}{\cancel{I_4}} = I_5$

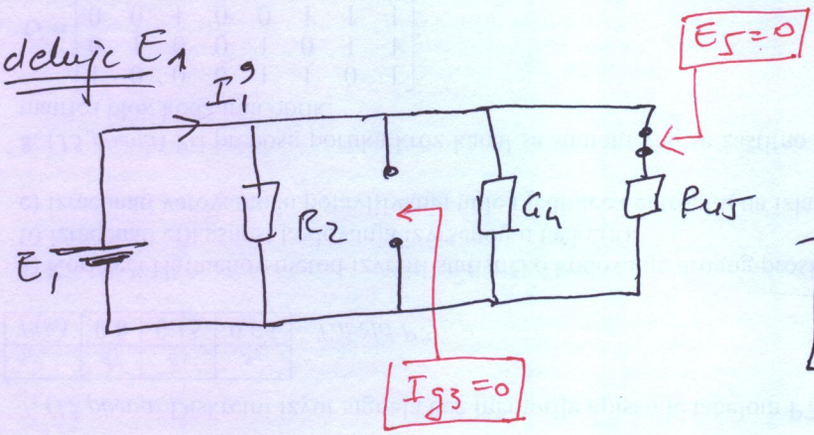
$$I_N = I_5 - I_3 = \frac{E_5}{R_{W5}} - I_{g3}$$

Primer 8



Odrediti I_1 principom teoreme superpozicije

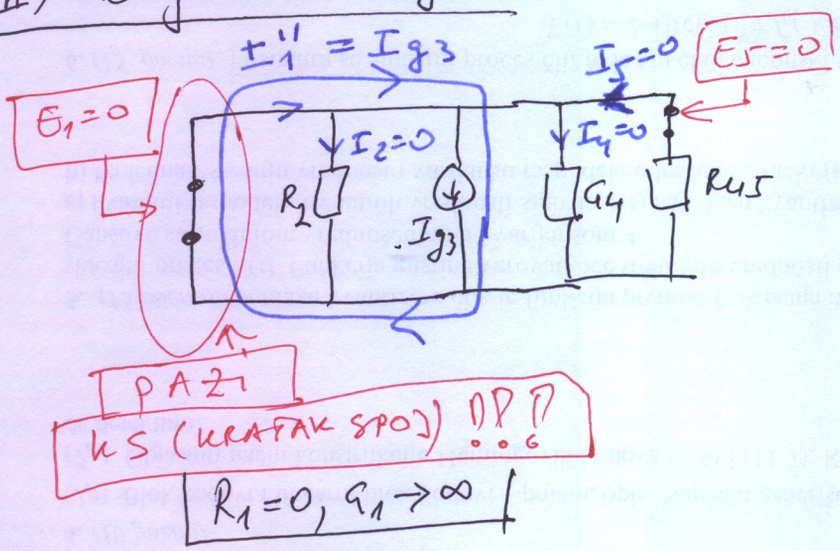
I) deluje E_1



$$R_{ekv} = \frac{1}{\frac{1}{R_2} + G_4 + \frac{1}{R_{u5}}}$$

$$I_1' = \frac{E_1}{R_{ekv}} = E_1\left(\frac{1}{R_2} + G_4 + \frac{1}{R_{u5}}\right)$$

II) deluje samo I_{g3}

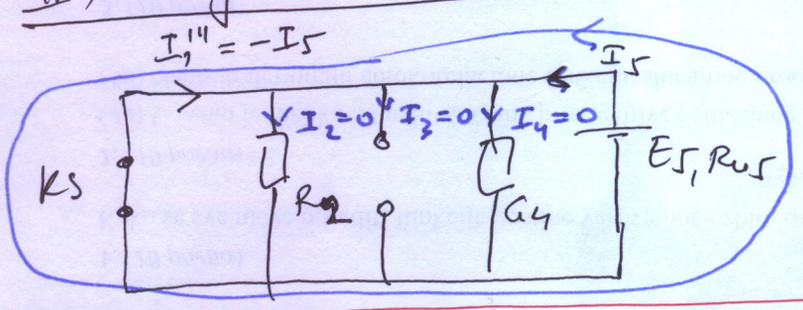


$$R_{ekv} = \frac{1}{\frac{1}{R_2} + G_4 + \frac{1}{R_{u5}} + \underbrace{\frac{1}{R_1}}_{\to\infty}} = 0$$

SVA STRUJA I_{g3} PROLAZI KROZ kS (gde je bio E_1)

$$I_1'' = I_{g3}$$

III) deluje samo E_5



$$E_5 - R_{u5} I_5 = 0$$

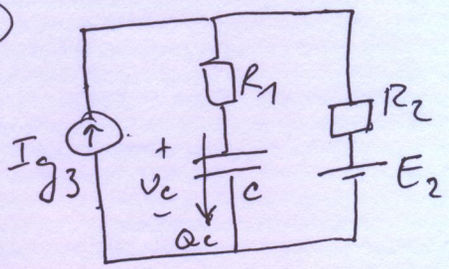
$$I_5 = \frac{E_5}{R_{u5}}$$

$$I_1''' = -I_5 = -E_5/R_{u5}$$

SUPERPOZICIJA: $I_1 = I_1' + I_1'' + I_1''' = \frac{E_1}{R_2} + G_4 E_1 + \frac{E_1}{R_{u5}} + I_{g3} - \frac{E_5}{R_{u5}}$

Primer 9

(*)

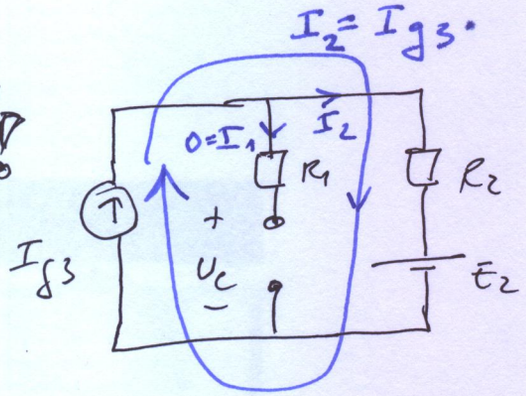


$Q_c = C U_c$

$Q_c = C(R_2 I_{g3} + E_2)$

$I_c = 0$!

$\Rightarrow$



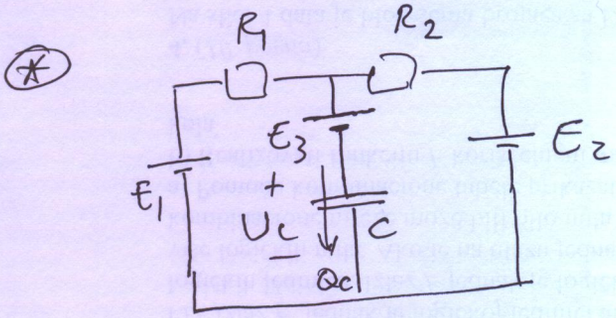
$I_1 = I_c = 0$

$I_2 = I_{g3}$

$U_c = -R_1 I_1 + R_2 I_2 + E_2$ ($I_1 = 0$, $I_2 = I_{g3}$)

$U_c = R_2 I_{g3} + E_2$

(*)

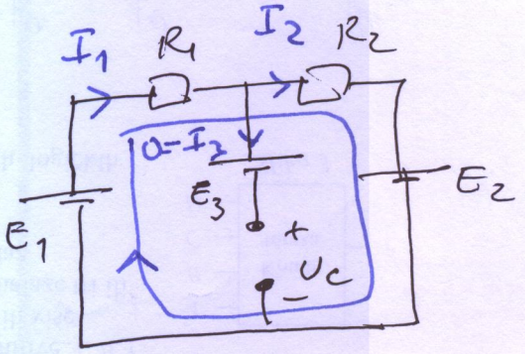


$Q_c = C U_c$

$Q_c = C U_c$

$Q_c = \frac{R_2}{R_1+R_2} E_1 C + \frac{R_1}{R_1+R_2} E_2 C - E_3 C$

$I_c = 0$! $\Rightarrow$



$I_3 = I_c = 0$

$I = I_1 = I_2$!

$-E_1 + R_1 I_1 + R_2 I_2 + E_2 = 0$

$I = I_1 = I_2 = \frac{E_1 - E_2}{R_1 + R_2}$

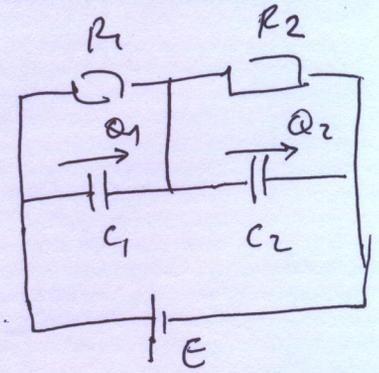
$U_c = R_2 I_2 + E_2 - E_3$

PAZI!

OBIČNO SE ZABORAVI

$U_c = \frac{R_2}{R_1+R_2}(E_1 - E_2) + E_2 - E_3$

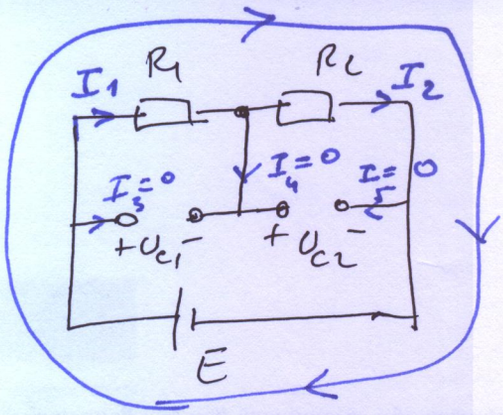
(*)



$I_{C_1} = 0$

$\Rightarrow$

$I_{C_2} = 0$



$I = I_1 = I_2$

$$Q_{c1} = C_1 U_{c1} = \frac{R_1 C_1 E}{R_1 + R_2}$$

$$Q_{c2} = C_2 U_{c2} = \frac{R_2 C_2 E}{R_2 + R_1}$$

$I_{C_1} = I_{C_2} = 0 \Rightarrow I_3 = I_4 = I_5 = 0$

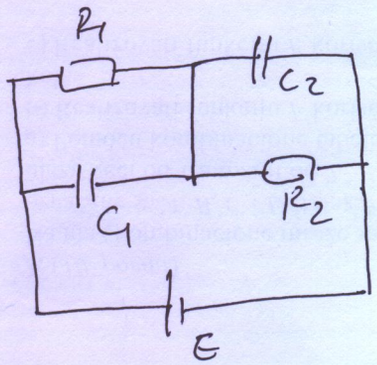
$I = I_1 = I_2$

$$I = \frac{E}{R_1 + R_2}$$

$$U_{c1} = R_1 I_1 = \frac{R_1}{R_1 + R_2} E$$

$$U_{c2} = R_2 I_2 = \frac{R_2}{R_1 + R_2} E$$

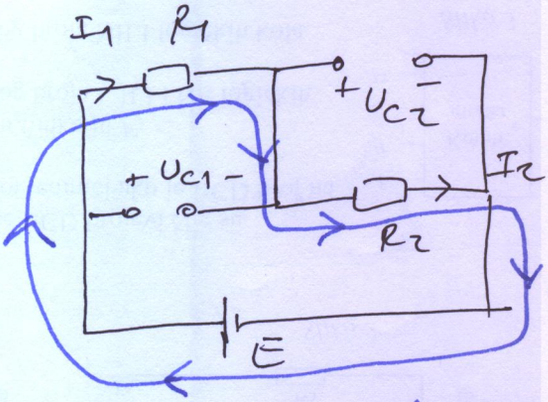
(*)



$I_{C_1} = 0$

$I_{C_2} = 0$

$\Rightarrow$



$I = I_1 = I_2$

isto Rešenje kao prethodni primer