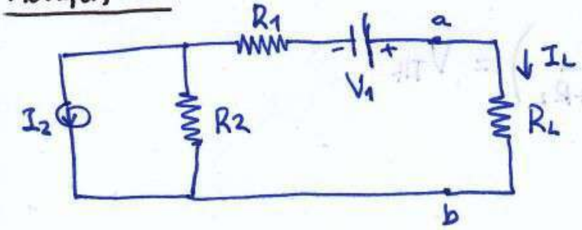
Ηλεκτρονική Ι

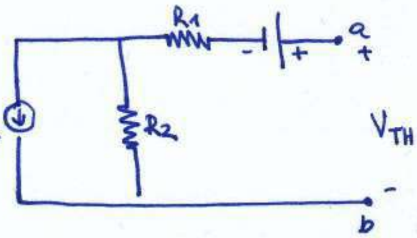
4ο Εξάμηνο, 2019-2020

Χρήστος Τσούφης
03117176

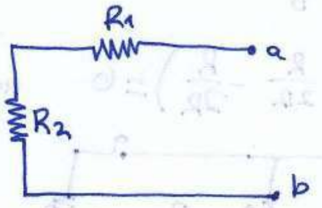
1η Σειρά Ασκήσεων

Άσκηση 1



1)


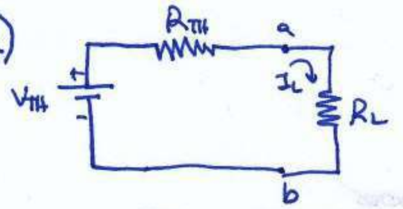
Αφού ανοιχτοκυκλώνω την I_2 και βραχυκυκλώνω την V_1 προκύπτει:



$R_{Th} = R_1 + R_2$

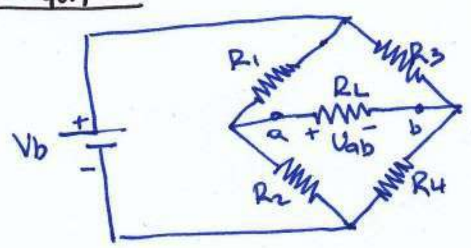
Όμως $V_{th} = V_1$ και $V_1 - I_2 R_2 = V_{ab}$ (ΝΤΚ)

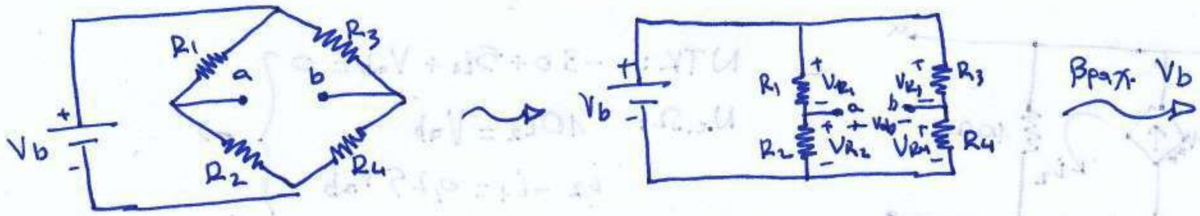
Επομένως, $V_{th} = V_{ab} = V_1 - I_2 R_2$.

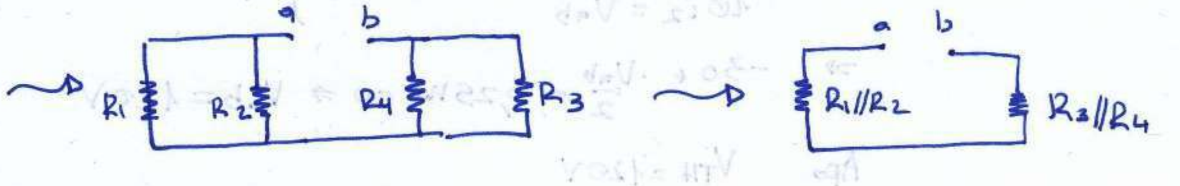
2)


$$I_L = \frac{V_{TH}}{R_{TH} + R_L} = \frac{V_1 - I_2 R_2}{R_1 + R_2 + R_L}$$

Άσκηση 2



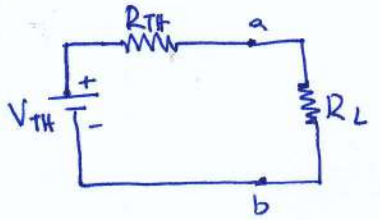
1)




$$R_{TH} = \frac{R_1 \cdot R_2}{R_1 + R_2} + \frac{R_3 \cdot R_4}{R_3 + R_4}$$

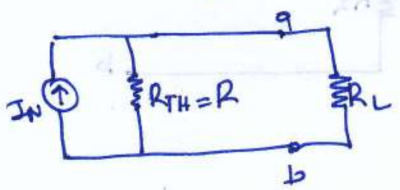
$$V_{R_1} = V_b \cdot \frac{R_1}{R_1 + R_2} \quad , \quad V_{R_3} = V_b \frac{R_3}{R_3 + R_4}$$

NTK: $V_{ab} + V_{R_1} - V_{R_3} = 0 \Rightarrow V_{ab} = V_b\left(\frac{R_2}{R_3 + R_4} - \frac{R_1}{R_1 + R_2}\right) = V_{TH}$



2) $V_{TH} = V_b\left(\frac{R}{2R} - \frac{R}{2R}\right) = 0$ και $R_{TH} = \frac{R^2}{2R} + \frac{R^2}{2R} = R$

Άρα,



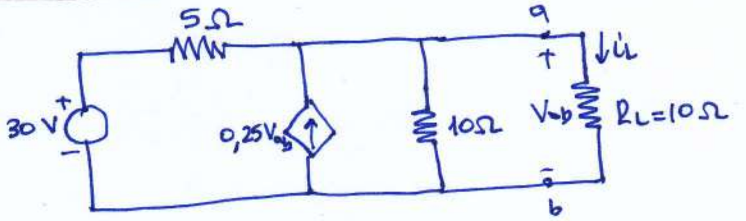
$V_{TH} = R_{TH} \cdot I_N \Rightarrow I_N = 0$

3) $V_{TH} = 20\left(\frac{3}{3+4} - \frac{1}{1+2}\right) = 20\left(\frac{3}{7} - \frac{1}{3}\right) = 20\left(\frac{9}{21} - \frac{7}{21}\right) = \frac{40}{21}$ V

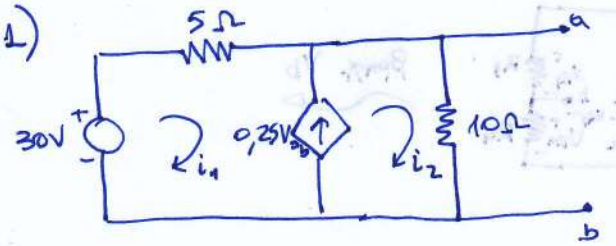
$R_{TH} = \frac{1 \cdot 2}{1+2} + \frac{3 \cdot 4}{3+4} = \frac{2}{3} + \frac{12}{7} = \frac{14}{21} + \frac{36}{21} = \frac{50}{21}\ \Omega$

Άρα, $V_{ab} = V_{TH} \cdot \frac{R_{TH}}{R_{TH} + R_L} = \frac{40}{21} \cdot \frac{\frac{50}{21}}{\frac{50}{21} + 10} = \frac{40}{21} \cdot \frac{\frac{50}{21}}{\frac{260}{21}} = \frac{200\cancel{0}}{26\cancel{0} \cdot 21} = \frac{200}{26 \cdot 21} = \frac{100}{13 \cdot 21} \simeq 0{,}36$ V

Άσκηση 3



1)



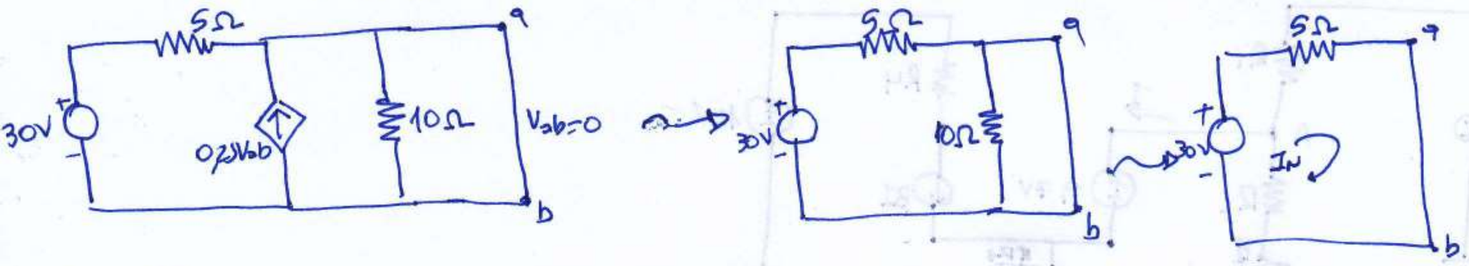
$$\left.\begin{array}{l} \text{NTK: } -30 + 5i_1 + V_{ab} = 0 \\ \text{N.ε.Ω: } 10i_2 = V_{ab} \\ \qquad i_2 - i_1 = 0{,}25V_{ab} \end{array}\right\} \Rightarrow$$

$$\Rightarrow \left.\begin{array}{l} -30 + 5i_2 - 1{,}25V_{ab} + V_{ab} = 0 \\ 10i_2 = V_{ab} \end{array}\right\} \Rightarrow$$

$$\Rightarrow -30 + \frac{V_{ab}}{2} - 0{,}25V_{ab} = 0 \Rightarrow V_{ab} = 120V$$

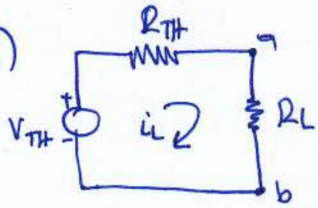
Άρα $V_{TH} = 120V$

Για να βρω R_{TH}, βραχυκυκλώνω στο a,b:



$$I_N = \frac{30}{5} = 6A \Rightarrow R_{TH} = R_N = \frac{V_{ab}}{I_N} = \frac{120}{6} = 20\,\Omega$$

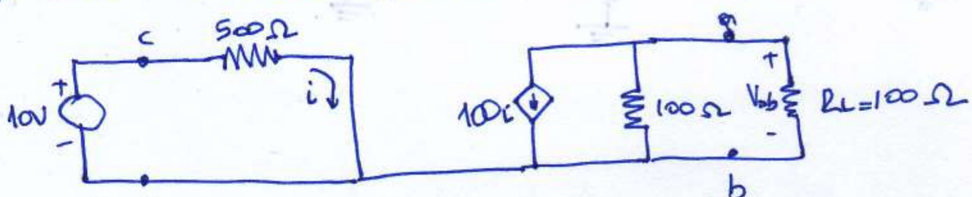
2)



$$i_L = \frac{V_{TH}}{R_{TH}+R_L} = \frac{120}{30} = 4A$$

Άσκηση 4

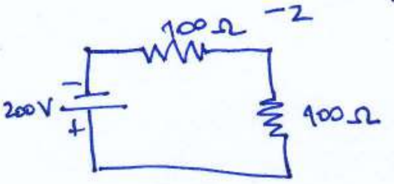
1) $k=0 \Rightarrow k \cdot V_{ab} = 0$ Βραχυκύκλωμα



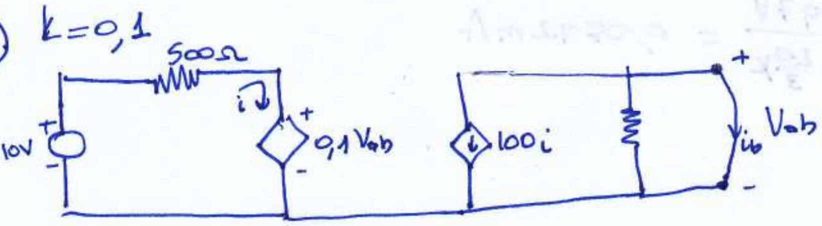
NTK: $-10 + 500i = 0 \to i = \frac{10}{500} = \frac{1}{50} = 0{,}02\,A$

Άρα, $100i = 2A \Rightarrow V_{ab} = -2 \cdot 100 = -200V = V_{TH}$

$R_{TH} = \frac{V_{TH}}{-2} = 100\,\Omega$



2) $k = 0{,}1$

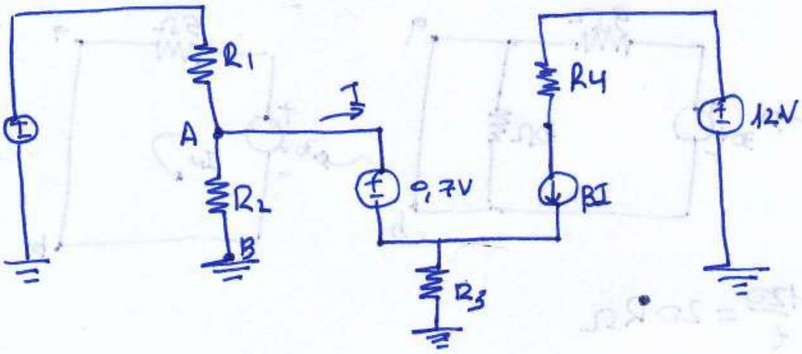


Βραχυκυκλώνω τα άκρα a,b, $V_{ab} = 0$. Άρα, $0{,}1V_{ab} = 0$.

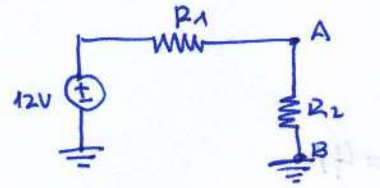
Επίσης $i_b = -2A$ (από (1.) ερωτ.)

NTK: $-10 + 500i \pm 0{,}1V_{ab} = 0 \Rightarrow i = \frac{-0{,}1V_{ab} + 10}{500}$

Άσκηση 5

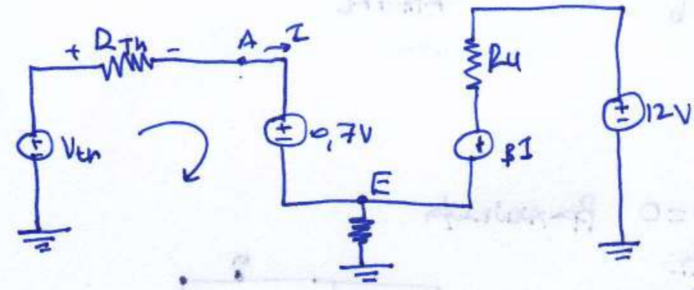


Thevenin στα A,B:



$V_{th} = 12V \cdot \frac{R_2}{R_1+R_2} = 4V$

$R_{th} = R_1 \| R_2 = \frac{20}{3} k\Omega$



$V_4 = -\beta \cdot I \cdot R_4 \quad (1)$

ΝΡΚ (E): $I + \beta I = \frac{V_E}{R_3} \quad (2) \Rightarrow (\beta+1) I = \frac{V_E}{R_3}$

ΝΤΚ: $V_{th} - I \cdot R_{th} - 0{,}7V = V_E \quad (3)$

$V_E = I(\beta+1)R_3$

Η (3): $V_{th} - IR_{th} - 0{,}7 = I(\beta+1)R_3$

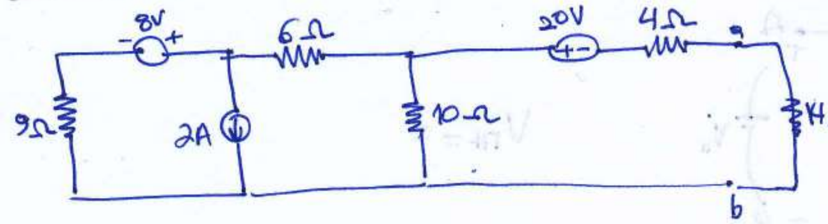
$\Leftrightarrow I[(\beta+1)R_3 + R_{th}] = V_{th} - 0{,}7$

$\Leftrightarrow I = \frac{V_{th} - 0{,}7}{(\beta+1)R_3 + R_{th}} = \frac{4V - 0{,}7V}{51 \cdot 1k + \frac{20}{3}k} = 0{,}0572 mA$

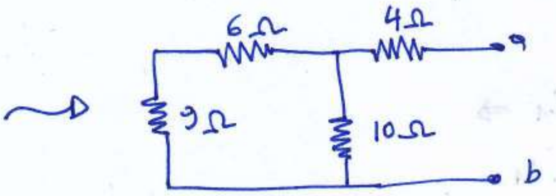
(1): $V_4 = -\beta I R_4 = -5{,}72V$

Λειτουργεί ως BJT σε DC λειτουργία στην ενεργό περιοχή.
Ουσιαστικά είναι ένα ισοδύναμο μοντέλο μεγάλου σήματος.

Άσκηση 6

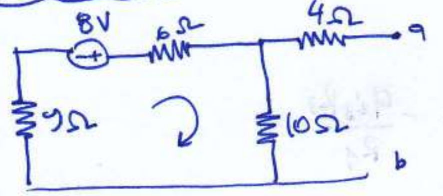


Βραχ. 8V, 20V
ανοιχ. 2A

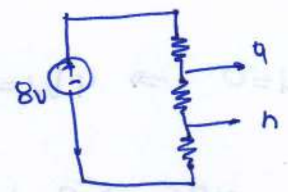


$R_{TH} = ((15)//10) + 4 = 10\Omega$

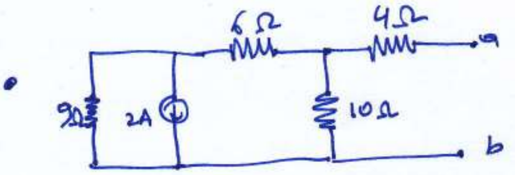
Αρχή επαλληλίας

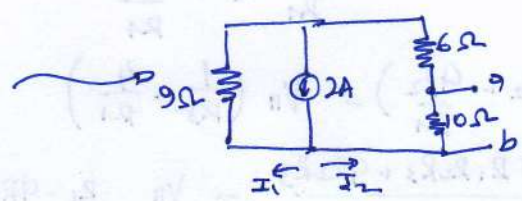
• 

Η 4Ω δεν διαρρέεται από ρεύμα



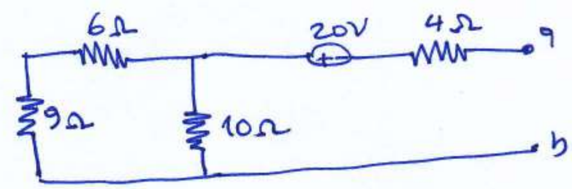
$$V_{ab} = V_a - V_b = 8 \cdot \frac{10+9}{10+9+6} - 8 \cdot \frac{9}{10+9+6} = \frac{10}{10+9+6} \cdot 8 = 3{,}2V$$

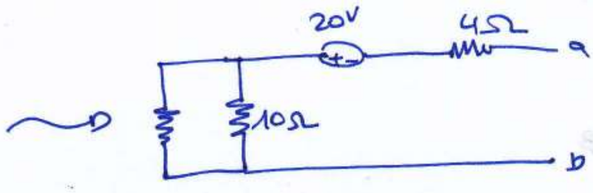
• 

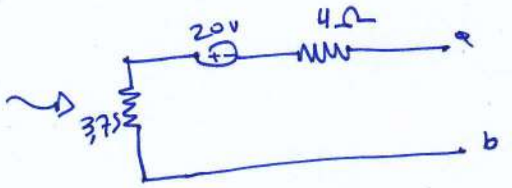


$$\left.\begin{aligned} &I_1 + I_2 = 2 \\ &9I_1 = 16I_2 \\ &\hookrightarrow I_1 = \tfrac{16}{9} I_2 \end{aligned}\right\} \Rightarrow \frac{16}{9} I_2 + \frac{9}{9} I_2 = 2 \Rightarrow \frac{25}{9} I_2 = 2 \Rightarrow I_2 = \frac{18}{25} A$$

$$V_{ab} = -\frac{180}{25} = -7{,}2V$$

• 

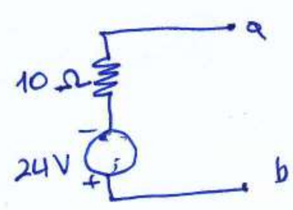




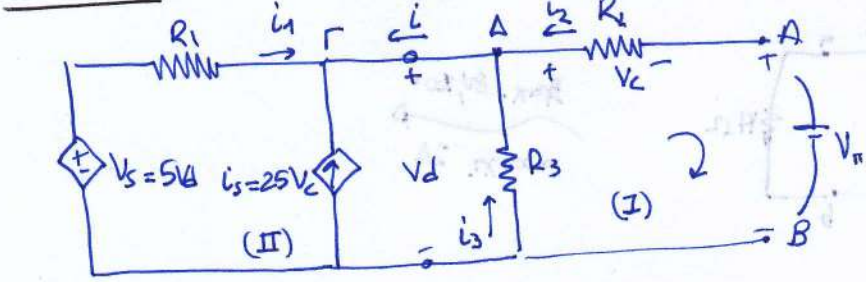
Αντιστάσεις δεν διαρρέονται από ρεύμα: $V_{ab} = -20V$

$V_{ab} = V_{TH} = -24V$

Άρα



Άσκηση 7



$V_{TH} = 0$

NPK Γ: $i_1 + i + 25V_c = 0$

NPK Δ: $i_2 + i_3 = i$

$\Rightarrow i_2 = -i_3 - 25V_c - i_1 \Rightarrow$

$\Rightarrow i_2 = -i_3 - 25\cdot i_2R_2 - i_1$

NTK (I): $V_\Pi + i_3R_3 + V_c = 0 \longrightarrow i_3 = -\dfrac{i_2R_2 + V_\Pi}{R_3}$

$V_c = -i_2R_2$

NTK (II): $-5V_d + i_1R_1 + V_d = 0 \Rightarrow 4V_d = i_1R_1 \Rightarrow i_1 = -\dfrac{4i_3R_3}{R_1}$

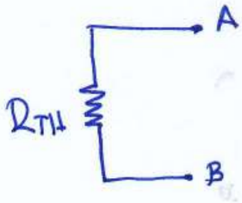
Άρα, $i_2 = \dfrac{V_\Pi + i_2R_2}{R_3} + 25i_2R_2 = \dfrac{4R_3}{R_1}\cdot\dfrac{i_2R_2 + V_\Pi}{R_3}$

$i_2 = \dfrac{V_\Pi}{R_3} + i_2\dfrac{R_2}{R_3} + 25R_2i_2 - \dfrac{4R_2}{R_1}\cdot i_2 - \dfrac{4V_\Pi}{R_1}$

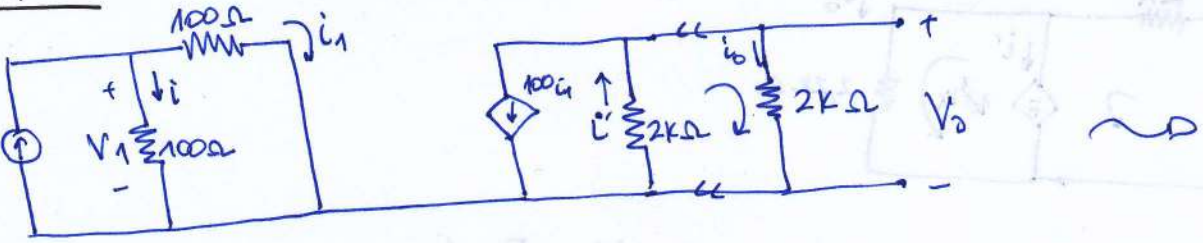
$\Rightarrow i_2\left(1 - \dfrac{R_2}{R_3} - 25R_2 + \dfrac{4R_2}{R_1}\right) = V_\Pi\left(\dfrac{1}{R_3} - \dfrac{4}{R_1}\right)$

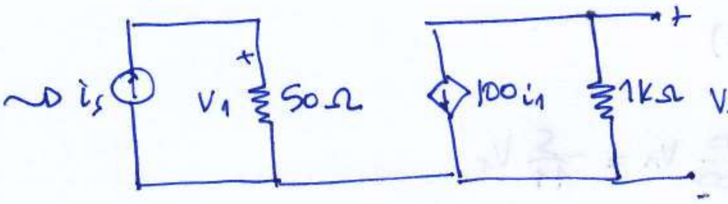
$\Rightarrow i_2\,\dfrac{R_3R_1 - R_2R_1 - 25R_1R_2R_3 + 4R_2R_3}{R_1\cancel{R_3}} = V_\Pi\,\dfrac{R_1 - 4R_3}{\cancel{R_1R_3}}$

$\Rightarrow i_2 = V_\Pi\,\dfrac{(R_1 - 4R_3)}{R_3R_1 - R_2R_1 - 25R_1R_2R_3 + 4R_2R_3} \longrightarrow R_{TH}$



Άσκηση 8





$V_1 = i_s \cdot 50$

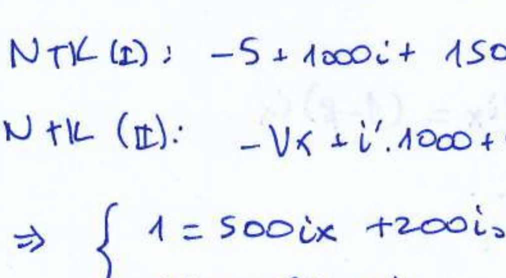
$V_o = -100 i_1 \cdot 1k$ $\Rightarrow$ $\frac{V_o}{V_1} = \frac{-100 \cdot 1000 i_1}{50 i_s} = -2000 \frac{i_1}{i_s} = -1000$

$i_s = i_1 + i = \frac{V_1}{100} + \frac{V_1}{100} = 2 i_1$

$i' = i_o + 100 i_1 \Rightarrow i' = i_o + 50 i_s$

ΝΤΚ: $i_o \cdot 2k + 2k \cdot i' = 0 \Rightarrow i_o = -i'$ $\Bigg\} \Rightarrow i_o = -25 i_s \Rightarrow \frac{i_o}{i_s} = -25$

Άσκηση 9



$i = i_x + i' + 10^{-3} V_x$

$i' + 10^{-3} V_x = i_o \Rightarrow i' = i_o - 10^{-3} V_x$

$\Rightarrow i = i_x + i_o \quad (*)$

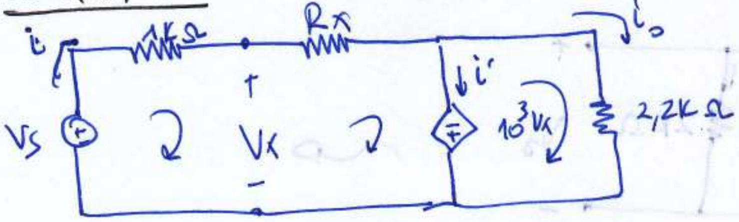
ΝΤΚ (Ι): $-5 + 1000 i + 1500 i_x = 0 \xRightarrow{(*)} 5 = 2500 i_x + 1000 i_o$

ΝΤΚ (ΙΙ): $-V_x + i' \cdot 1000 + 4700 i_o = 0 \xRightarrow{(*)} -V_x - V_x + i_o \cdot 1000 + 4700 i_o = 0$

$\Rightarrow \begin{cases} 1 = 500 i_x + 200 i_o \\ 2 V_x = 5700 i_o \end{cases} \Rightarrow \begin{cases} 1 = 500 i_x + 200 i_o \\ 3000 i_x = 5700 i_o \end{cases} \Rightarrow 1 = 500 \cdot \frac{57}{30} i_o + 200 i_o$

$\Rightarrow i_o = \frac{1}{1150} \Rightarrow V_o = \frac{4700}{1150} = 4{,}086 V$

Άσκηση 10



$$-V_X + R_X \cdot i - 10^3 V_X = 0 \Rightarrow R_X \cdot i = 1001 V_X \Rightarrow V_X = \frac{R_X \cdot i}{1001} \quad (1)$$

$$-V_S + 1000 i + V_X = 0 \Rightarrow V_X = V_S - 1000 i \quad (2)$$

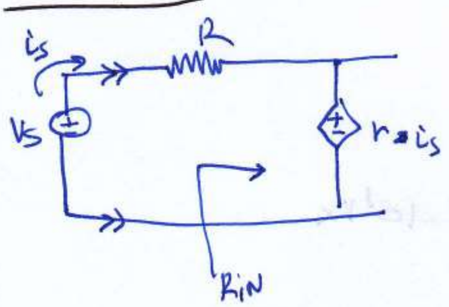
$$10^3 V_X + 2200 i_o = 0 \quad (3) \Rightarrow i_o = -\frac{1000}{2200} V_X = -\frac{5}{11} V_X$$

$$i_o = -\frac{5}{11} V_X \quad , \quad V_S = \frac{R_X \cdot i}{1001} + 1000 i$$

$$\frac{i_o}{V_S} = \frac{-\frac{5}{11} R_X \cdot \frac{i}{1001}}{\left(\frac{R_X}{1001} + 1000\right) i} = -\frac{\frac{5}{11} \cdot R_X}{R_X + 10^3 \cdot 1001} \Rightarrow -\frac{5}{22} = \frac{-5 R_X}{11 R_X + 10^3 \cdot 11 \cdot 1001} \Rightarrow$$

$$\Rightarrow \frac{11 R_X + 10^3 \cdot 11 \cdot 1001}{22} = R_X \Rightarrow R_X + 10^3 \cdot 1001 = 2 R_X \Rightarrow R_X = 1001 k\,\Omega$$

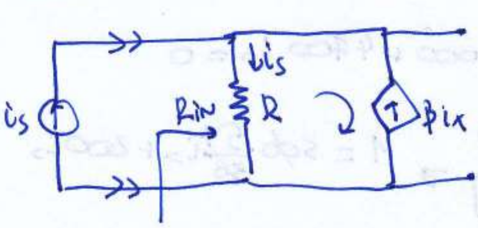
Άσκηση 11



ΝΤΚ: $-V_S + R i_S + r i_S = 0 \Rightarrow \frac{V_S}{i_S} = R + r$

Οπότε, $R_{in} = R + r$

Άσκηση 12

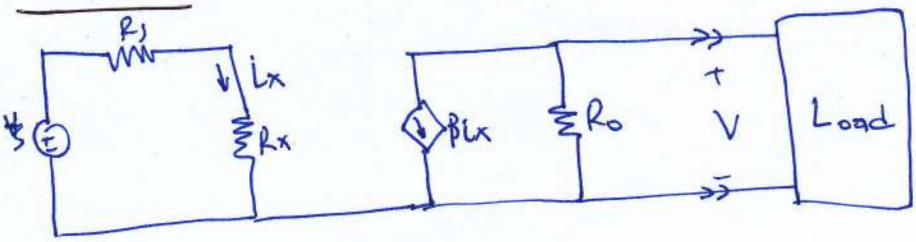


ΝΡΚ: $i_S = i_X - \beta i_X = (1-\beta) i_X$

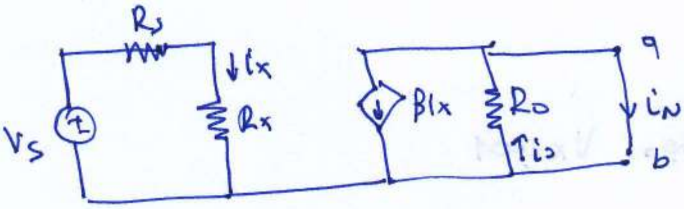
$$\Rightarrow i_X = \frac{i_S}{1-\beta}$$

$$V_S = i_X \cdot R \Rightarrow \frac{V_S}{i_S} = \frac{R \cdot i_X}{(1-\beta) i_X} = \frac{R}{1-\beta} = R_{in}$$

Άσκηση 13



$$-V_s + i_x(R_x+R_s) = 0 \Rightarrow i_x = \frac{V_s}{R_s+R_x}$$



$\beta i_x + i_N = i_o$

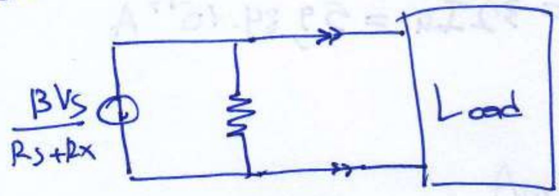
Όμως, $V_{ab} = 0 \rightsquigarrow R_o \cdot i_o = 0 \Rightarrow i_o = 0$

$$\beta i_x = -i_N \Rightarrow i_N = -\frac{\beta V_s}{R_s+R_x}$$

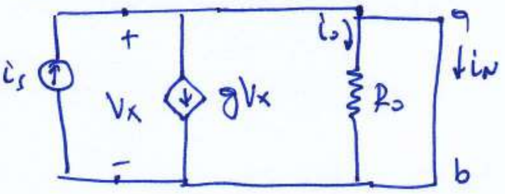
Ανοιχτ. a, b: $V_{ab} = -\beta i_x \cdot R_o = -\frac{\beta V_s \cdot R_o}{R_s+R_x}$

$$R_N = \frac{V_{ab}}{i_N} = +R_o$$

Άρα,



Άσκηση 14



$i_N + g V_x + i_o = i_s$

$V_{ab} = 0 \Rightarrow i_o R_o = 0 \Rightarrow i_o = 0 \Rightarrow V_x = 0$

Άρα $i_N = i_s$

Ανοιχτ. a, b: $V_{ab} = i_o R_o = R_o (i_s - g V_x)$

$\hookrightarrow V_{ab} = R_o (i_s - g V_{ab})$

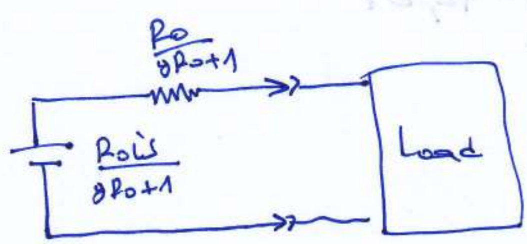
$$V_{ab} = \frac{R_o \cdot i_s}{g R_o + 1}$$

$i_o + g V_x = i_s$

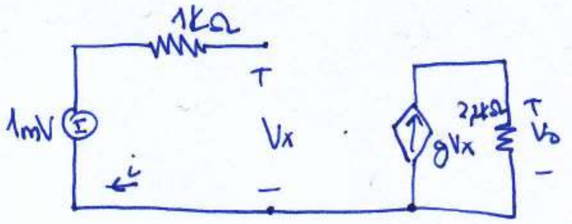
$V_x = i_o R_o = V_{ab}$

$$R_{TH} = \frac{V_{ab}}{i_N} = \frac{R_o}{g R_o + 1}$$

Οπότε,



Άσκηση 15



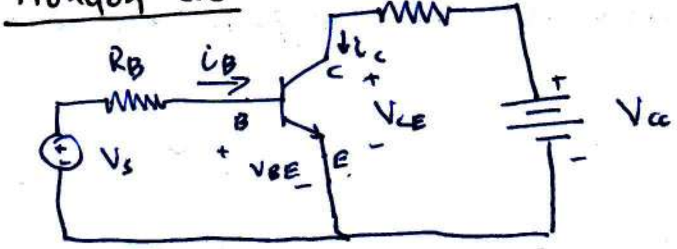
$$V_o = gV_x \cdot 2200 \overset{V_o=10}{\Rightarrow} g = \frac{1}{220 V_x}$$

$-0{,}01 + 1000i + V_x = 0$

$V_x = 0{,}001 - 1000i$ όμως $i=0$ λόγω ανοιχ. Άρα: $V_x = 0{,}01$

Άρα $g = \frac{1}{0{,}22} \simeq 4{,}54\ \Omega^{-1}$

Άσκηση 16



$R_B = 100 K\Omega$

$R_C = 3{,}3 K\Omega$

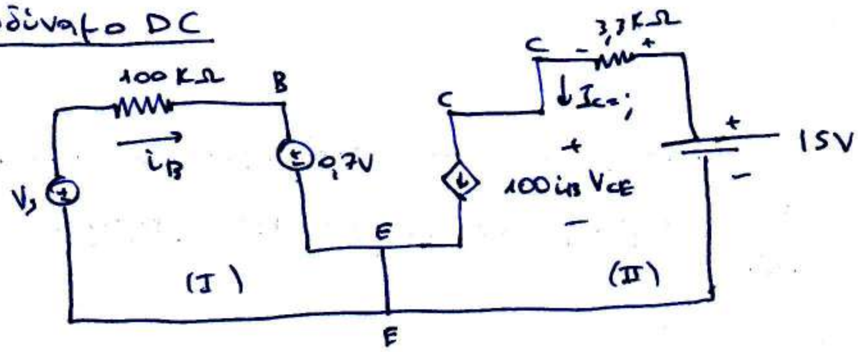
$\beta = 100$

$V_{BE} = 0{,}7V$

$V_{CC} = 15V$

$u_s = \begin{cases} 1V \\ 5V \end{cases}$

Ισοδύναμο DC



- για $U_S = 1V$:

NTK (I): $V_S = 100K\Omega i_B + 0{,}7V \Rightarrow i_B = 3\mu A$

$I_C = 100 i_\beta = 0{,}3mA$

NTK (II): $15V = 3{,}3K\Omega \cdot 0{,}3mA + V_{CE} \Rightarrow V_{CE} = 14{,}01V$

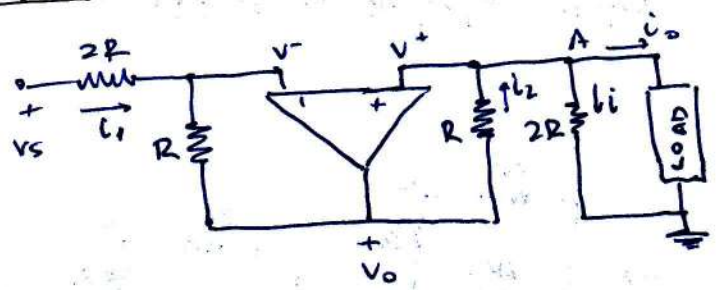
- για $V_S = 5V$:

NTK(I): $5V = 100K\Omega \cdot i_B + 0{,}7V \Rightarrow i_B = 43\mu A$

$I_C = 100 i_\beta = 4{,}3mA$

NTK(II): $15V = 3{,}3K\Omega \cdot 4{,}3mA + V_{CE} \Rightarrow V_{CE} = 0{,}81V$

Άσκηση 17



ισχύει $V^+ = V^- = V$

Για 2R: $i_1 = \frac{V - V_S}{2R}$ (1) Το ίδιο ρεύμα διαρρέει και την R (αριστερά).

Άρα, $i_1 = \frac{V_o - V}{R}$ (2)

$(1) = (2) \Rightarrow \frac{V - V_S}{2R} = \frac{V_o - V}{R} \Rightarrow 3V = 2V_o + V_S$ (α)

· Δεξιά του op-amp: $i_2 = \frac{V_o - V}{R}$ (3) και διασπάζεται στον κόμβο A σε i_o και i.

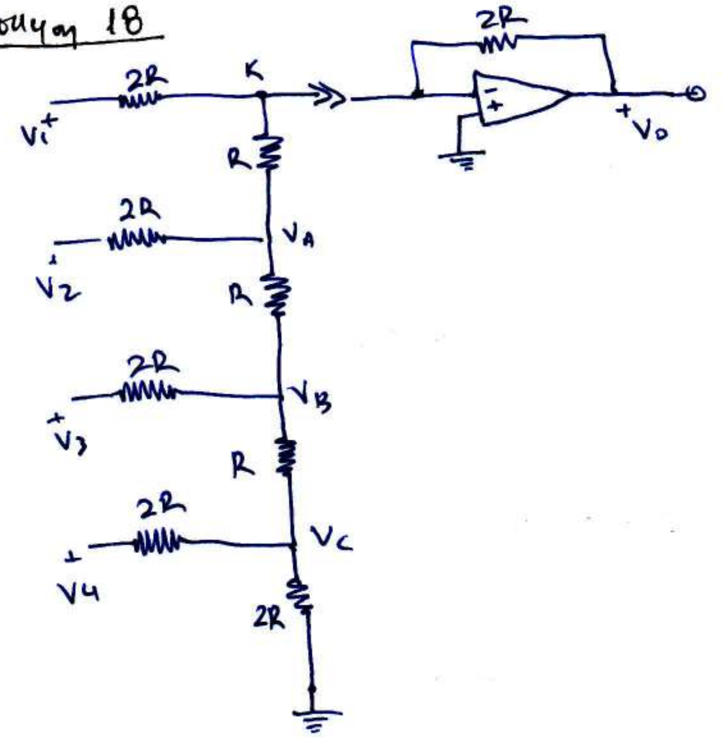
Άρα $i_2 = i_o + i \Rightarrow i_2 = i_o + \frac{V}{2R}$ (4)

$(3)=(4) \Rightarrow \frac{V_o - V}{R} = i_o + \frac{V}{2R} \Rightarrow 2V_o - 2V = 2Ri_o + V \Rightarrow 2V_o - 2Ri_o = 3V$ (β)

· (α) & (β) $\Rightarrow 2V_o + V_s = 2V_o - 2Ri_o \Rightarrow i_o = -\frac{V_s}{2R}$

· Παρ: Η τιμή του ρεύματος που διαρρέει το φορτίο είναι ανεξάρτητη από αυτό και έχει σταθερή τιμή ίση με $-\frac{V_s}{2R}$. Δηλαδή, αποτελεί μια πηγή ρεύματος εξαρτώμενη από τάση.

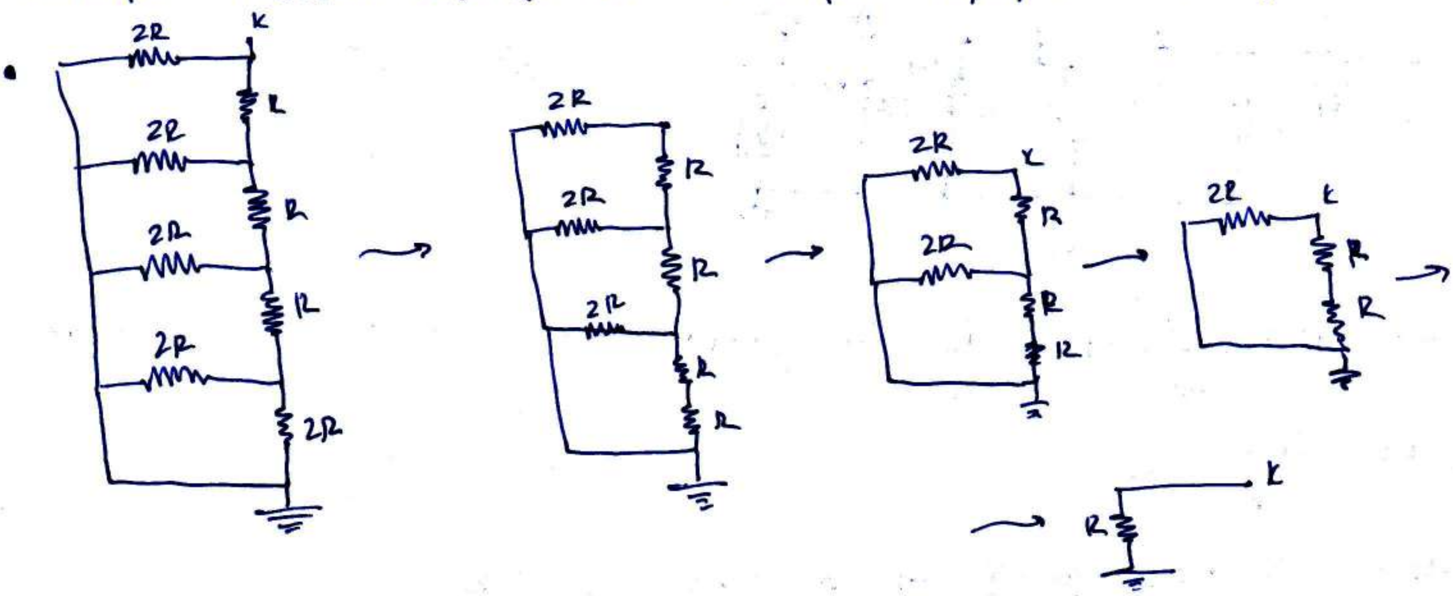
Άσκηση 18



$V_1 = V_2 = V_4 = 5V$

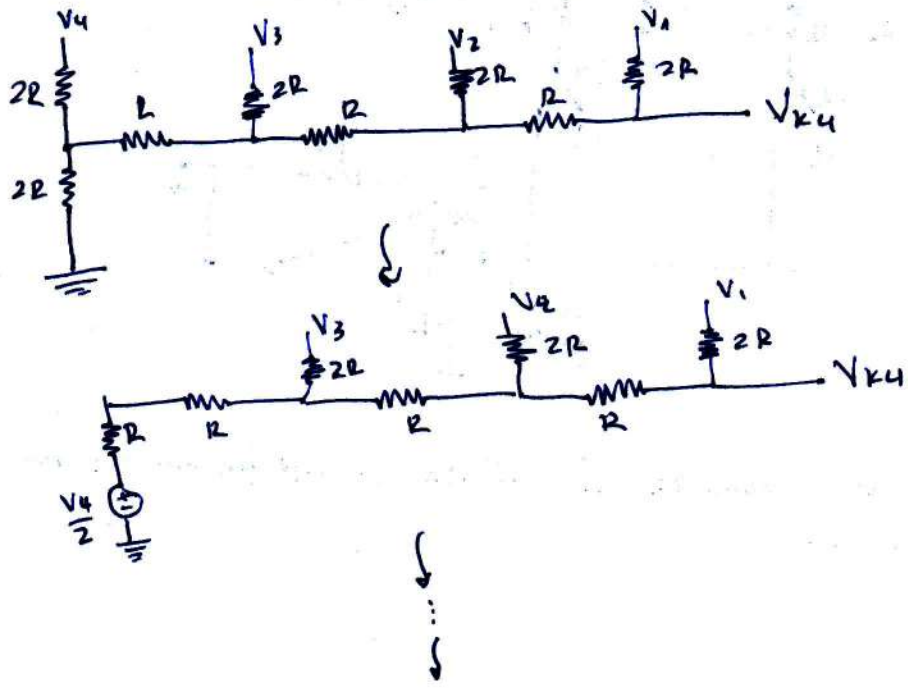
$V_3 = 0V$

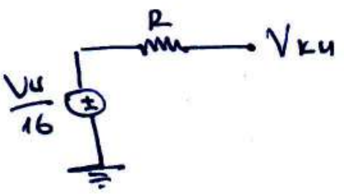
▷ Ισοδύναμο Thevenin (αριστερά του K) (θεωρούμε V_1, V_2, V_4 συνεχ. πηγές τάσης)



Άρα $R_{TH} = R$

• Βραχυκυκλώνουμε όλες τις πηγές εκτός V_4 :

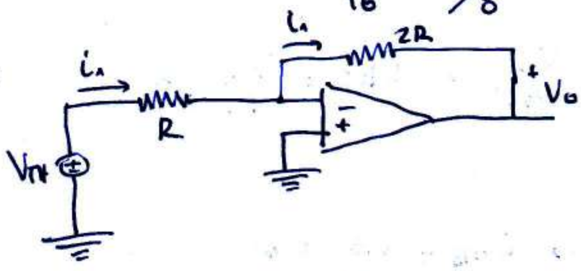




δηλ. $V_{\kappa 4} = \dfrac{V_4}{16}$

Ομοίως, $V_{\kappa 3} = \dfrac{V_3}{8}$, $V_{\kappa 2} = \dfrac{V_2}{4}$, $V_{\kappa 1} = \dfrac{V_1}{2}$

Οπότε $V_{TH} = \dfrac{V_4}{16} + \cancel{\dfrac{V_3}{8}}^{0} + \dfrac{V_2}{4} + \dfrac{V_1}{2} = \dfrac{5}{16} + \dfrac{5}{4} + \dfrac{5}{2} \Rightarrow V_{TH} = 4,0625\ V$



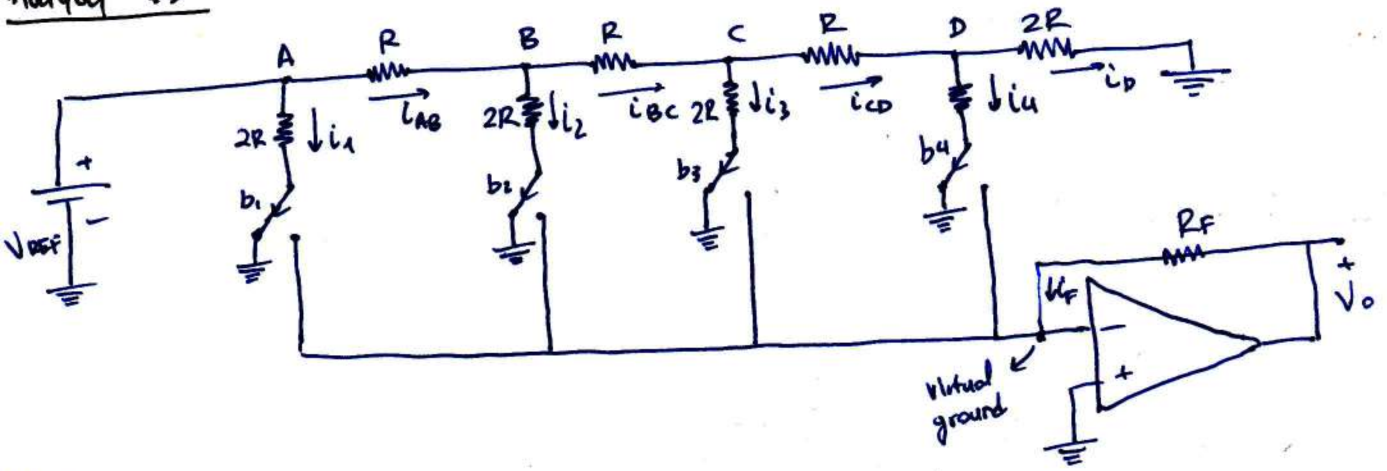
ισχύει $V^+ = V^-$, όμως $V^- = 0$ άρα και $V^+ = 0$.

• $i_1 = \dfrac{V_{TH} - 0}{R}$ (1)

και $i_1 = \dfrac{0 - V_o}{2R}$ (2)

$\Big\} \Rightarrow \dfrac{V_{TH}}{R} = -\dfrac{V_o}{R} \Rightarrow V_o = -8,125\ V$

Άσκηση 19



(1) Φαίνεται ότι $V_A = V_{REF}$

Επίσης το ρεύμα που διαρρέει τις αντιστάσεις δεν αλλάζει με την μετακίνηση του διακόπτη από νόμο του Ohm, θα έχουμε:

$$i_1 = \frac{V_A - 0}{2R} \Rightarrow i_1 = -\frac{V_{REF}}{2R}$$

- $V_A - V_B = i_{AB} \cdot R \Rightarrow V_B = V_A - i_{AB} \cdot R \quad (1)$
- $V_B - V_C = i_{BC} \cdot R \Rightarrow V_C = V_B - i_{BC} \cdot R \quad (2)$
- $V_C - V_D = i_{CD} \cdot R \Rightarrow V_D = V_C - i_{CD} \cdot R \quad (3)$

όμως $i_4 = i_D = \frac{V_D}{2R}$ και $i_4 + i_D = i_{CD}$, άρα $i_{CD} = \frac{V_D}{R} \quad (4)$

$$(3) \overset{(4)}{\Rightarrow} V_D = V_C - \frac{V_D}{R} \cdot R \Rightarrow 2V_D = V_C \quad (5)$$

και $i_{BC} = i_3 + i_{CD} = \frac{V_C}{2R} + \frac{V_D}{R} \overset{(5)}{=} \frac{V_C}{2R} + \frac{V_C}{2R} \Rightarrow i_{BC} = \frac{V_C}{R} \quad (6)$

$$(2) \overset{(6)}{\Rightarrow} V_C = V_B - \frac{V_C}{R} \cdot R \Rightarrow 2V_C = V_B \quad (7)$$

και $i_{AB} = i_2 + i_{BC} = \frac{V_B}{2R} + \frac{V_C}{R} \overset{(7)}{=} \frac{V_B}{2R} + \frac{V_B}{2R} \Rightarrow i_{AB} = \frac{V_B}{R} \quad (8)$

$$(1) \overset{(8)}{\Rightarrow} V_B = V_A - \frac{V_B}{R} \cdot R \Rightarrow 2V_B = V_A$$

Όμως $V_A = V_{REF} \Rightarrow V_B = \frac{V_A}{2} = \frac{V_{REF}}{2}$

όμως $2V_C = V_B \Rightarrow V_C = \frac{V_B}{2} = \frac{V_{REF}}{4}$ και $V_D = \frac{V_C}{2} = \frac{V_{REF}}{8}$ κλπ

Άρα, $i_1 = \frac{V_{REF}}{2R}$, $i_2 = \frac{V_B}{2R} = \frac{V_{REF}}{2^2 R}$,

$i_3 = \frac{V_C}{2R} = \frac{V_{REF}}{2^3 R}$, $i_4 = \frac{V_D}{2R} = \frac{V_{REF}}{2^4 R}$

(2) Στον αναστρέφοντα ακροδέκτη τελικά φτάνουν τα ρεύματα:

$b_1 \cdot i_1 + b_2 \cdot i_2 + b_3 \cdot i_3 + b_4 \cdot i_4 = i$

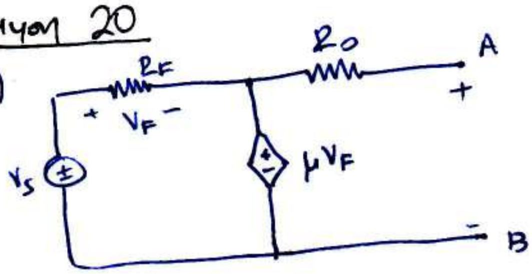
Οι συντελεστές b_1, b_2, b_3, b_4 προσδιορίζουν μόνο $b_j = 0$ και τότε ο ακροδέκτης j είναι στην πραγματική γη και άρα το ρεύμα i_j δεν φτάνει στον αναστρέφοντα ακροδέκτη, οπότε και αγνοείται από την σχέση, ενώ αν $b_j = 1$ τότε ο ακροδέκτης j είναι σε επαφή με τον αναστρέφοντα ακροδέκτη και άρα το ρεύμα i_j περνάει αυτούσιο. Επίσης, θυμηθείτε ότι μέσα στην ενίσχυση δεν υπάρχει ρεύμα.
Επομένως $\sum_{j=1}^{4} b_j i_j = -i_{REF}$

(3). Από N. Ohm για την αντίσταση ανάδρασης έχουμε: $V_o - 0 = i_F \cdot R_F =$

$$= -R_F \cdot \sum_{j=1}^{4} b_j \cdot i_j = -R_F \sum_{j=1}^{4} b_j \cdot \frac{V_{REF}}{2^j \cdot R} \Rightarrow V_o = -\frac{R_F \cdot V_{REF}}{2R} \cdot \sum_{j=1}^{4} b_j \cdot \frac{1}{2^{j-1}}$$

Άσκηση 20

(1)



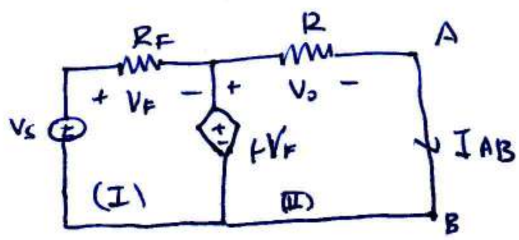
▷ Εύρεση ισοδύναμου Thevenin:

Οι ακροδέκτες A, B δεν διαρρέονται από ρεύμα, άρα ουσιαστικά έχουμε ένα βρόχο στο κύκλωμα.

ΝΤΚ: $V_S = V_F + \mu V_F \Rightarrow V_F = \frac{V_S}{1+\mu}$

$V_{AB} = V_{TH} = \mu V_F = \mu \frac{V_S}{1+\mu}$

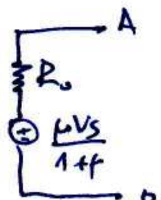
Για εύρεση I_{AB}, βραχυκυκλώνουμε τα A, B.



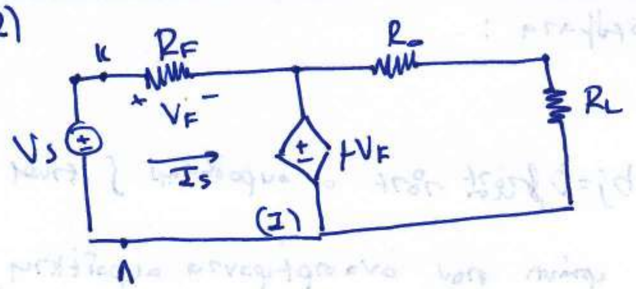
ΝΤΚ (Ι): $V_F = \frac{V_S}{1+\mu}$

ΝΤΚ (ΙΙ): $\mu V_F = V_o = \mu \frac{V_S}{1+\mu}$, όπως $V_o = R_o \cdot I_{AB} \Rightarrow I_{AB} = \frac{\mu V_S}{(1+\mu) \cdot R_o}$

Άρα $R_{TH} = \frac{V_{AB}}{I_{AB}} = \frac{\frac{\mu V_S}{1+\mu}}{\frac{\mu V_S}{(1+\mu) R_o}} = R_o$ Άρα



(2)



NTK (I): $V_S = V_F + \mu V_F \Rightarrow V_F = \dfrac{V_S}{1+\mu}$

Ομως $V_F = I_S \cdot R_F \Rightarrow I_S = \dfrac{V_S}{(1+\mu)\cdot R_F}$

Άρα $R_{IN} = \dfrac{V_S}{I_S} = \dfrac{V_S}{\frac{V_S}{(1+\mu)\cdot R_F}} = (1+\mu)\cdot R_F$