Ηλεκτρονική Ι

4ο Εξάμηνο, 2018-2019

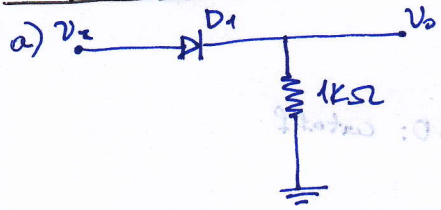
3η Σειρά Ασκήσεων

Χρήστος Τσοφίνη

03117176

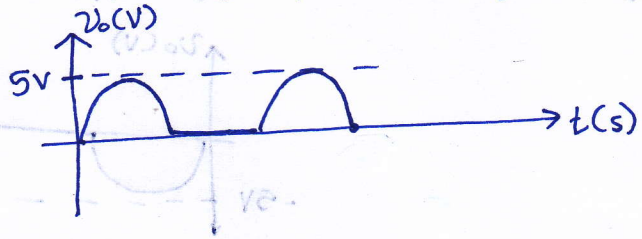
Άσκηση 1 (4.4)

a)



Όταν v_I θετική πρέπει: $v_I \le v_o \Rightarrow v_o = v_I$

-"- αρνητική -"- : $v_I \le v_o \Rightarrow 0V$



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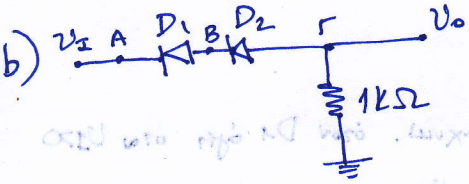
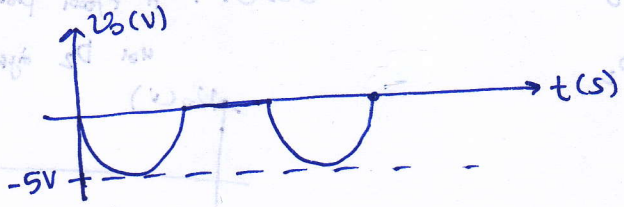
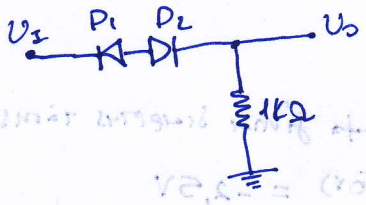


Αγουν: $v_B = v_\Gamma = v_o = v_I \Rightarrow v_o = 0$ $(v_I > 0)$

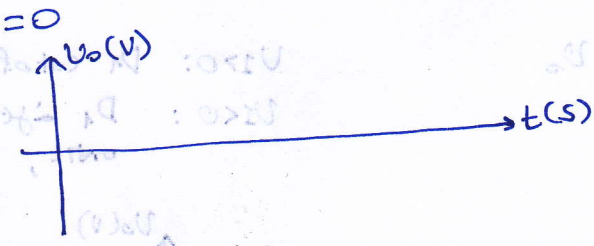
Αγουν: $v_{AB} = v_{B\Gamma} = v_I = v_o$ $(v_I < 0)$



c)



$v_o = 0$



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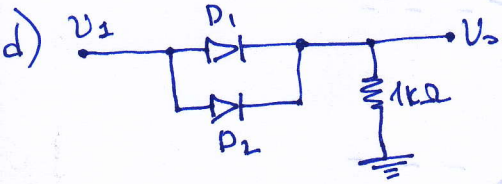
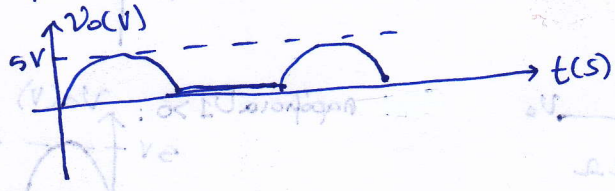


Ομοια με (a):



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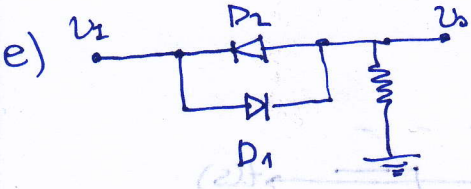
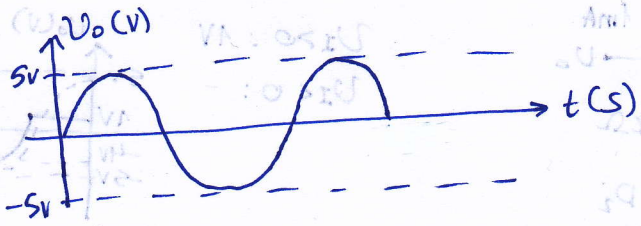
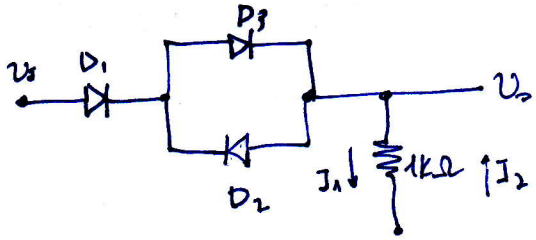


$v_I < 0$ ή $v_I > 0 \Rightarrow v_I = v_o$

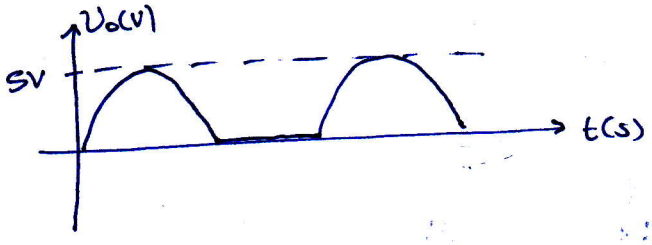


f)



$v_I > 0$: I_1

$v_I < 0$: –



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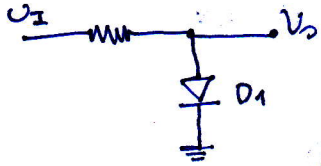
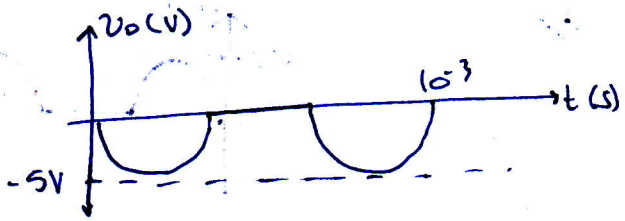
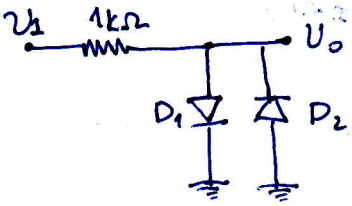


$v_I > 0$: D_1 βραχυκυκλ. $v_I < 0$: cutoff

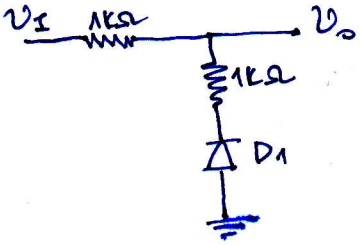


h)



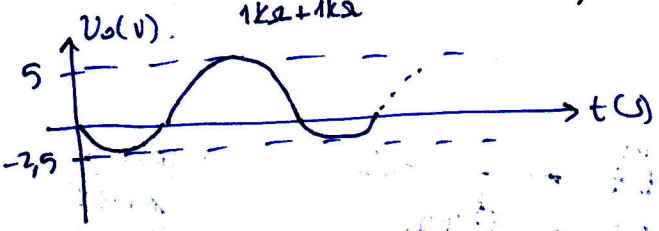
$v_o = 0V$: Η εξόδος μόνιμο βραχυκυκ. όταν D_1 άγει όταν $v_I > 0$ και D_2 άγει όταν $v_I < 0$

i)

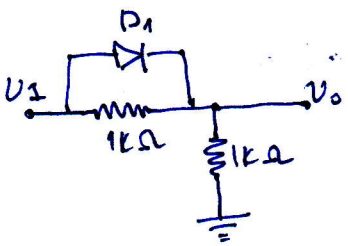


$v_I > 0$: D_1 cutoff

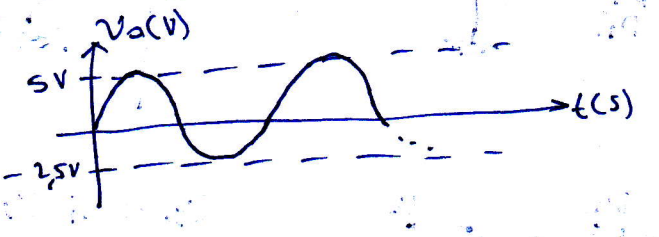
$v_I < 0$: D_1 άγει, το κύκλωμα γίνεται διαιρέτης τάσης οπότε, $\frac{1k\Omega}{1k\Omega + 1k\Omega} \cdot (-5,V) = -2,5V$



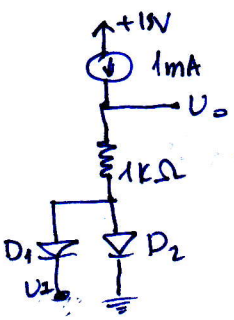
j)



παράμοια:

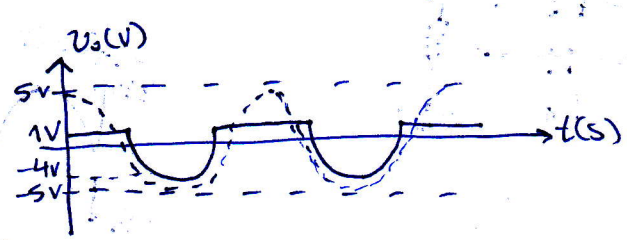


k)



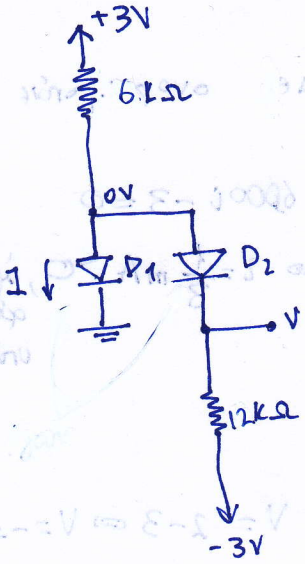
$v_I > 0$: 1V

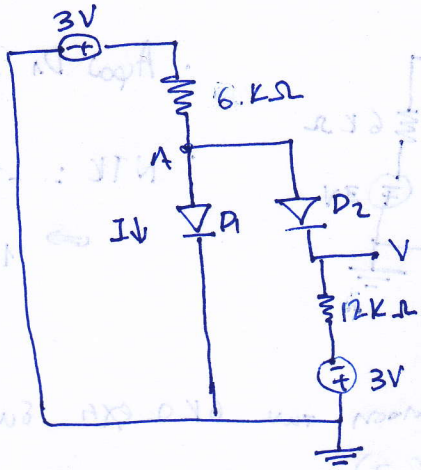
$v_I < 0$: –



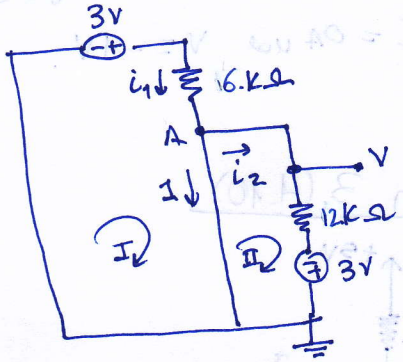
Άσκηση 2 (4.9)

β)





Αν D_1, D_2 άγουν θεωρούμε βραχυκ. οπότε: $V_{D1} = V_{D2} = 0$:



ΝΤΚ (I): $-3 + 6.000 \cdot i_1 = 0 \Rightarrow i_1 = \frac{1}{2} = 0{,}5\ mA$.

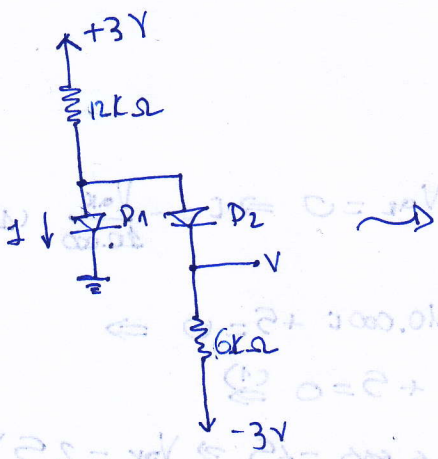
ΝΤΚ (II): $i_2 \cdot 12.000 - 3 = 0 \Rightarrow i_2 = \frac{1}{4} = 0{,}25\ mA$

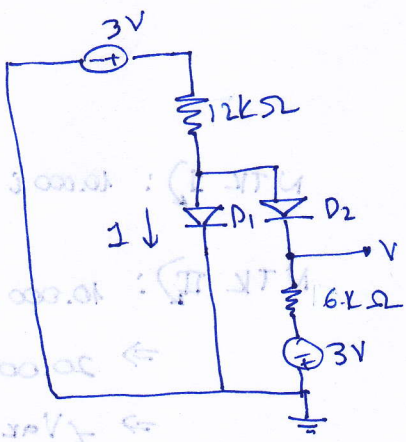
Άρα, $i(D_1) = 0{,}5\ mA > 0$ και $i(D_2) = i_2 > 0$. (ορθή η αρχική υπόθεση, δηλ. D_1, D_2 άγουν).

Οπότε, ΝΡΚ Α: $I = i_1 - i_2 = 0{,}5\ mA - 0{,}25\ mA \Rightarrow I = 0{,}25\ mA$

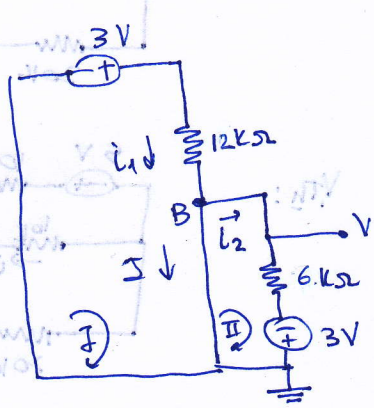
Επειδή η D_1 άγει και ιδανική βραχυκ., $V_A = 0$ και άρα $V = 0\ V$.

α)





Άρα D_1, D_2 άγουν
$V_{D1} = V_{D2} = 0$

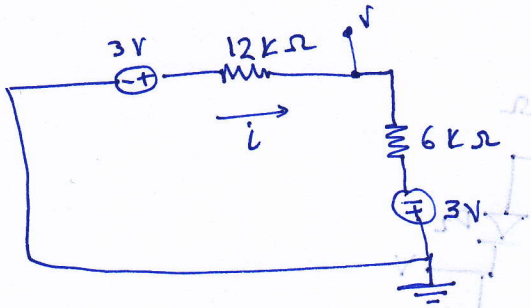


ΝΤΚ (I): $-3 + 12.000 \cdot i_1 = 0 \Rightarrow i_1 = 0{,}25\ mA$

ΝΤΚ (II): $i_2 \cdot 6.000 - 3 = 0 \Rightarrow i_2 = 0{,}5\ mA$

ΝΡΚ Β: $I = i_1 - i_2 = 0{,}25 - 0{,}5 = -0{,}25\ mA < 0$. (μη ορθή η αρχική υπόθεση)

Υποθέτουμε ότι D_2 άγει και η D_1 όχι. Προκύπτει ότι:



∴ Αφού D_1 δεν άγει, απότελεί ανοιχτό, οπότε $I=0$

ΝΤΚ: $-3+12.000\cdot i+6000i-3=0$

$\Leftrightarrow 18.000i=6 \Leftrightarrow i=\frac{1}{3}mA>0$, άρα σωστή υπόθεση.

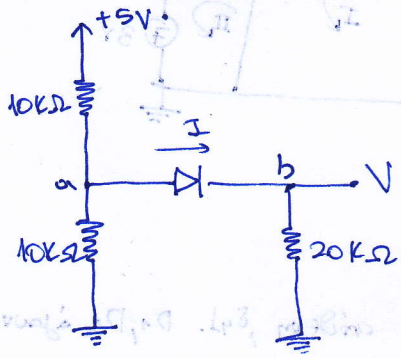
- Στο κάτω άκρο της, η αντίσταση των 6KΩ έχει δυναμικό $-3V$.

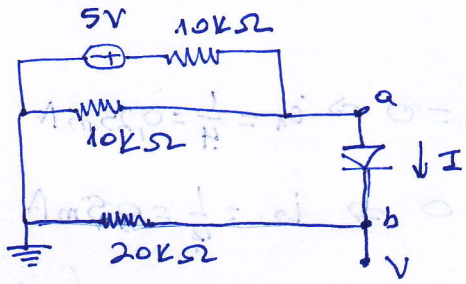
Για την V έχουμε: $\frac{V-(-3)}{6.000}=i \Leftrightarrow V+3=\frac{1}{3}\cdot 6.000\cdot 10^{-3} \Leftrightarrow V=2-3 \Leftrightarrow V=-1V$

Άρα $I=0A$ και $V=-1V$.

Άσκηση 3 (4.10)

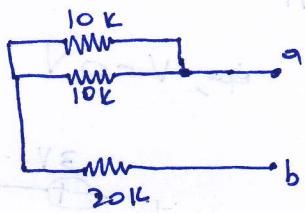
α)





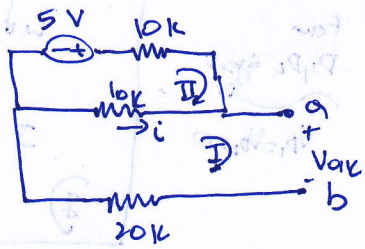
Ισοδύναμο Thevenin:

R_{Th}:



$R_{Th}=(10K//10K)+20K=\frac{10K\cdot 10K}{10K+10K}+20K=25K\Omega$

V_{ak}:



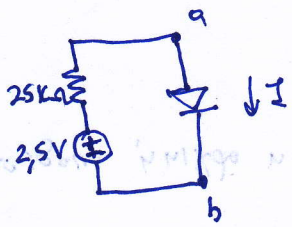
ΝΤΚ I): $10.000i+V_{ak}=0 \Rightarrow i=-\frac{V_{ak}}{20.000}$ (1)

ΝΤΚ II): $10.000i+10.000i+5=0 \Rightarrow$

$\Rightarrow 20.000i+5=0 \overset{(1)}{\Rightarrow}$

$\Rightarrow +\frac{V_{ak}}{10.000}\cdot 20.000=+5 \Rightarrow V_{ak}=2,5V$

Οπότε,

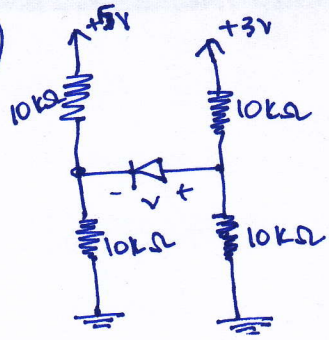


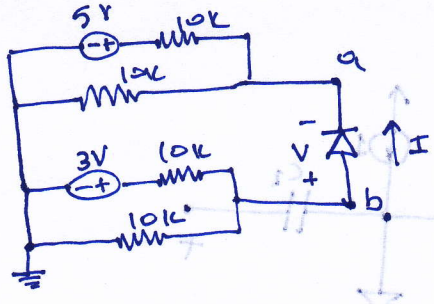
Άρα, η δίοδος είναι ορθά πολωμένη και άγει, με

$I=\frac{2,5}{25\cdot 10^3} \Rightarrow I=0,1mA$

και $V=V_b=I\cdot 20K\Omega=0,1\cdot 10^{-3}\cdot 20\cdot 10^3=2V$

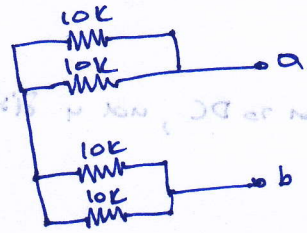
β)





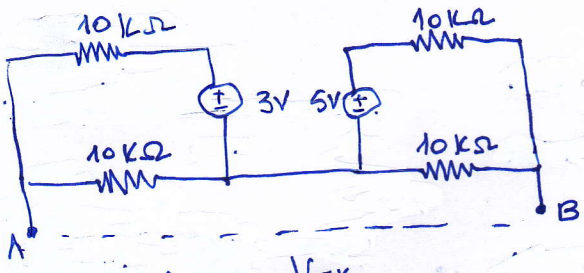
Ισοδύναμο Thevenin:

R_{Th} :



$R_{Th} = (10K \,//\, 10K) + (10K \,//\, 10K) = 10K\Omega$

V_{AK} :

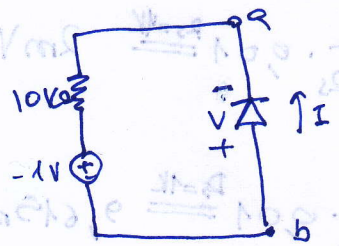


Διαίρεση τάσης:

- $V_A = \frac{10}{20} \cdot 3 = \frac{3}{2} V$
- $V_B = \frac{10}{20} \cdot 5 = \frac{5}{2} V$

Άρα $V_{AK} = V_A - V_B = -1V$

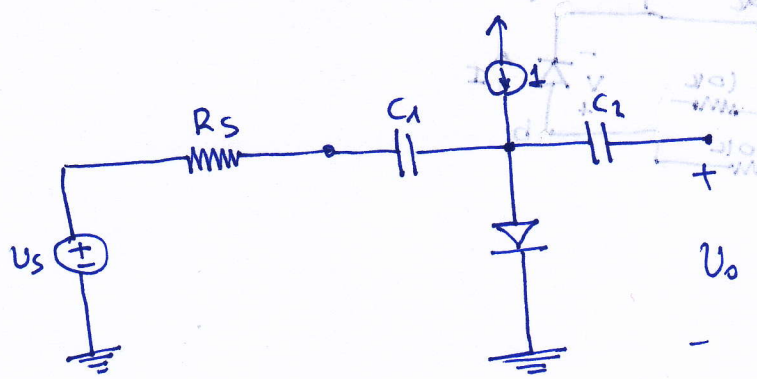
Όπότε,



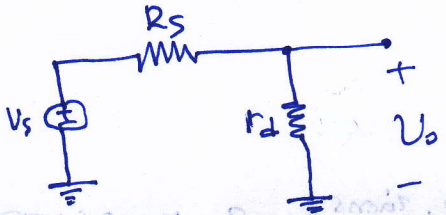
Η διόδος είναι ανάστροφα πολωμένη οπότε $I=0$.

Επειδή, $I=0$, η $R_{Th} = 10K\Omega$ είναι ηλεκτρικά αδιάφορη, θα είναι $V = -1V$.

Άσκηση 4. (4.48)



Για το μοντέλο μικρού σήματος: C_1, C_2 βραχυκ., κόβεται το DC, και η δίοδος αντικαθ. με r_d.



$$r_d = \frac{V_T}{I}$$

$$v_o = \frac{r_d}{r_d + R_s} \cdot v_s = \frac{\frac{V_T}{I}}{\frac{V_T}{I} + R_s} \cdot v_s = v_s \cdot \frac{V_T}{V_T + I \cdot R_s}$$

- για $I = 1mA$ και $v_s = 10mV$, $V_T = 25mV$ έχουμε: $v_o = \frac{V_T}{V_T + 0{,}001 \cdot R_s} \cdot 0{,}01 \overset{R_s = 1k}{=} 0{,}2439mV$

- για $I = 0{,}1mA$ και $v_s = 10mV$, $V_T = 25mV$ έχουμε: $v_o = \frac{V_T}{V_T + 10^{-4} \cdot R_s} \cdot 0{,}01 \overset{R_s = 1k}{=} 2mV$

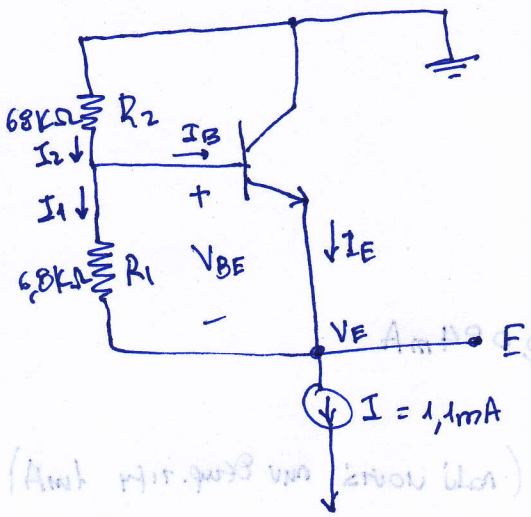
- για $I = 1\mu A$ και $v_s = 10mV$, $V_T = 25mV$ έχουμε: $v_o = \frac{V_T}{V_T + 10^{-6} R_s} \cdot 0{,}01 \overset{R_s = 1k}{=} 9{,}615mV$

- Για $R_s = 1k\Omega$, $V_T = 25mV$, $v_o = \frac{v_s}{2}$ έχουμε:

$$\frac{1}{2} v_s = v_s \left(\frac{0{,}025}{0{,}025 + I \cdot 10^3} \right) \Leftrightarrow \frac{1}{2} = \frac{0{,}025}{0{,}025 + I \cdot 10^3} \Leftrightarrow 0{,}05 = 0{,}025 + I \cdot 10^3 \Leftrightarrow$$

$$\Leftrightarrow I \cdot 10^3 = 0{,}05 - 0{,}025 \Leftrightarrow I \cdot 10^3 = 0{,}025 \Leftrightarrow I = 25\mu A$$

Άσκηση 5 (6.42)



Στους 25°C θεωρούμε $I_E = 1mA$. Έτσι, $V_{BE} = 0,68V$.

$$I_1 = \frac{V_{BE}}{R_1} = \frac{0,68V}{6,8K\Omega} = 0,1mA$$

$I_E = I - I_1 = 1,1 - 0,1 = 1mA$ (η τιμή αυτή είναι η ονομενόμενη)

$$I_2 = I_1 + I_B = I_1 + \frac{I_E}{\beta+1} = 0,1 + \frac{1}{101} = 0,11mA$$

· Σημειώνεται ότι τα ρεύματα στις R_1 και R_2 διαφέρουν μόνο από το μικρό ρεύμα βάσης 0,01mA.

· Αν I_1 και I_2 ήταν ίσα, τότε:

$$I_1R_1 = V_{BE}$$

$$I_2R_2 \simeq I_1R_2 = V_{BE}\frac{R_2}{R_1}$$

$$V_E = -(I_1R_1 + I_2R_2) = -V_{BE}\left(1+\frac{R_2}{R_1}\right) = -V_{BE}\left(1+\frac{6,8}{0,68}\right) = -11V_{BE} = -7,48V$$

το οποίο δίνει στο κύκλωμα το όνομα: πολλαπλασιαστής V_{BE}.

· Αν λειφθεί υπόψιν η I_B τότε: $V_E = -(I_1R_1 + I_2R_2) = -\left(V_{BE} + \frac{R_2}{R_1}V_{BE} + I_BR_2\right) =$

$$= -\underbrace{\left(1+\frac{R_2}{R_1}\right)V_{BE} - I_BR_2}_{(2)} = -7,48 - 0,01\cdot 68 \Rightarrow$$

$$\Rightarrow V_E = -8,16V$$

· Καθώς η θερμοκρασία αυξάνεται, μια προσέγγιση για του συντελεστή θερμοκρασίας TC του V_E μπορεί να υπολογιστεί θεωρώντας ότι το I_E παραμένει σταθερό και αγνοώντας το β. Έτσι, θα αγνοήσουμε την αλλαγή θερμοκρασίας των (I_BR_2) όρων στην εξ. (2). Από την εξ (2) και χρησιμοποιώντας το γεγονός ότι το V_{BE} αλλάζει $-2,2mV/°C$ προκύπτει ότι:

$TC = -\left(1 + \frac{R_2}{R_1}\right)(-2,2) = -11 \times (-2,2) = +24,2\ mV/^\circ C$

Στους 75°C (η θερμοκρασία αυξάνει 50°C):

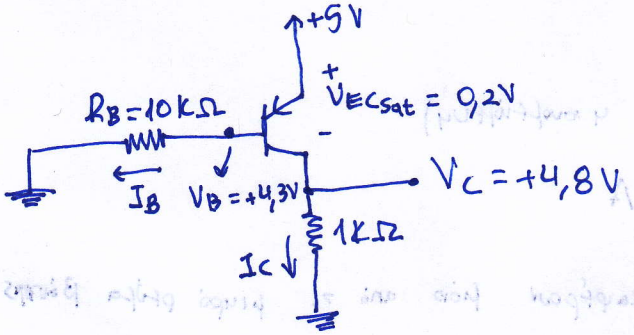
$V_E = -8,16 + 24,2 \cdot 50 = -6,95V$

Επαληθεύουν:

$I_1(75^\circ C) = \frac{V_{BE}(75^\circ C)}{R_1} = \frac{0,68 - 2,2 \cdot 10^{-3} \cdot 50}{6,8} = 0,084\ mA$

$I_E(75^\circ C) = I - I_1(75^\circ C) = 1,1 - 0,084 = 1,016 mA$ (πολύ κοντά στην θεωρητική 1mA)

Άσκηση 6 (6.50)



Θεωρώντας ότι λειτουργεί στο κορεσμό, προκύπτει:

$I_C = \frac{V_C}{1k\Omega} = \frac{4,8}{1} = 4,8mA$

$I_B = \frac{V_B}{R_B} = \frac{4,3}{10} = 0,43mA$

Έτσι, $\beta_{forced} = \frac{I_C}{I_B} = \frac{4,8}{0,43} = 11,2$

Αφού 11,2 πολύ μικρότερο από το $\beta = 50$, επαληθεύεται ότι το τρανζίστορ λειτουργεί στον κορεσμό, όπως υποτέθηκε.

$V_C = V_{CC} - V_{EC_{sat}} = 5 - 0,2 = 4,8V$

Για να λειτουργεί στο όριο κορεσμού:

$V_{EC} = 0,3V$ και $\frac{I_C}{I_B} = \beta = 50$

Έτσι, $I_C = \frac{5 - 0,3}{I} = 4,7\ mA$, $I_B = \frac{I_C}{\beta} = \frac{4,7}{50} = 0,094\ mA$,

$R_B = \frac{4,3}{I_B} = \frac{4,3}{0,094} = 45,7\ k\Omega$