jun '19

① a) $3R \| 6R = \frac{18R^2}{9R} = 2R$

$V_T = -2R(I_{G1} + I_{G2})$

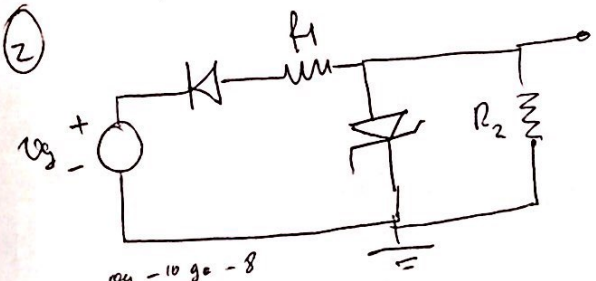
$R_T = 2R$

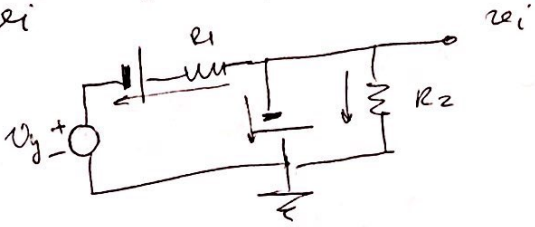
$\underline{V_{AB} = -2R(I_{G1} + I_{G2})}$

$P_{IG1} = 2R\, I_G (I_{G1} + I_{G2})$ $\quad P_{5R} = 0W$

$R_p = 2R$

② D: ON, DZ: προσοχή





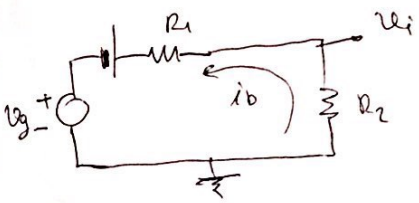
v_g -10 με -8

$\underline{v_i = -6V}$ 1° $\quad i_{R2} = -\frac{6V}{3k\Omega} = -2mA$

$i_{R2} \cdot R_2 - i_D R_1 - v_g - V_D = 0 \qquad -6{,}7 - i_D R_1 - v_g = 0$

$i_D = -\frac{v_g + 6{,}7V}{R_1} \qquad i_z = -(i_D + i_{R2}) = \frac{v_g + 6{,}7}{R_1} + 2mA = v_g + 8{,}7mA$

$\underline{\text{Για } v_g = -8{,}7V \text{ DZ} \rightarrow \text{OFF}}$



$v_g + V_D + i_D(R_1 + R_2)$

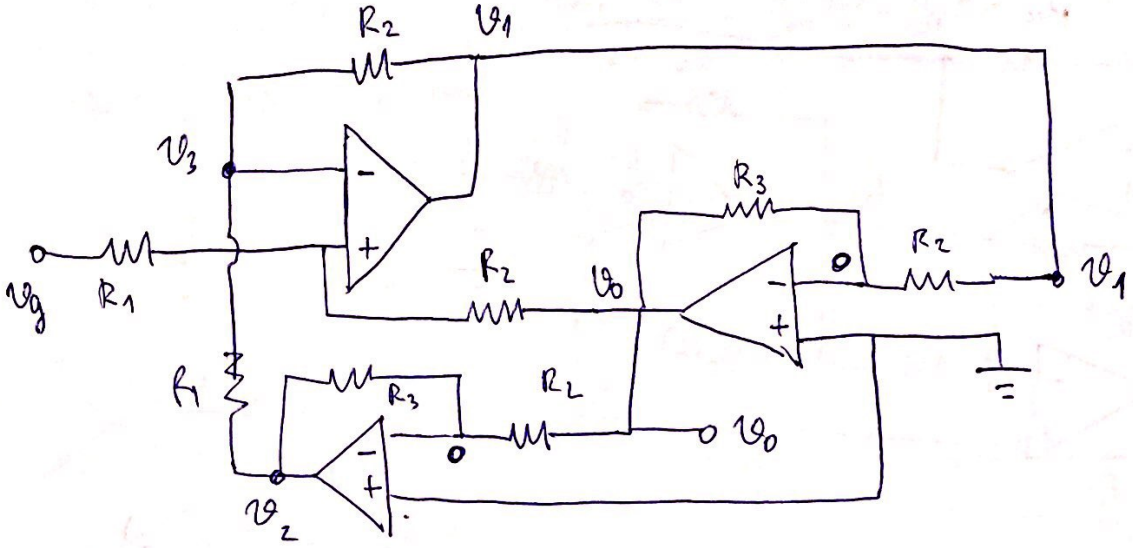
$i_D = -\frac{1}{4}v_g - 0{,}175 > 0$

Για $v_g = -0{,}7V$ D → OFF

$\underline{v_i = \frac{3}{4}v_g + 0{,}525}$ 2°

v_g -8 με -0,7V

$\underline{v_i = 0V}$ 3° v_g -0,7 με 10V



$$\frac{v_o}{R_3} = -\frac{v_1}{R_2} \qquad \boxed{v_1 = -\frac{2}{3} v_o}$$

$$\frac{v_o}{R_2} = -\frac{v_2}{R_3} \qquad \boxed{v_2 = -\frac{3}{2} v_o}$$

$$\frac{v_2 - v_3}{R_1} = \frac{v_3 - v_1}{R_2} \qquad 2v_2 - 2v_3 = v_3 - v_1$$

$$3v_3 = 2v_2 + v_1 \qquad v_3 = \frac{2}{3} v_2 + \frac{1}{3} v_1$$

$$v_3 = -v_o - \frac{2}{9} v_o = -\frac{11}{9} v_o$$

$$\frac{v_g - v_3}{R_1} = \frac{v_3 - v_o}{R_2} \qquad 2v_g - 2v_3 = v_3 - v_o$$

$$v_o = 3v_3 - 2v_g = -\frac{11}{3} v_o - 2v_g$$

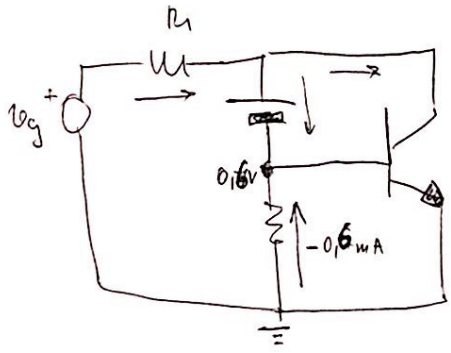
$$\frac{14 v_o}{3} = -2v_g \qquad \boxed{v_o = -\frac{3}{7} v_g}$$

a) üü : Q: OFF, DZ: OFF

$v_{DZ} = -1V \quad v_{BE} = 0V$

$v_c = 1V$

b) üü: Q: gap, DZ: ürmeler



$v_c = 3V$

$0,6 + 3V + i_B R_1 - v_g = 0$

$i = \frac{8 - 3,6}{R_1} = 2,2mA$

$2,2mA = (1+\beta) i_B + 0,6mA$

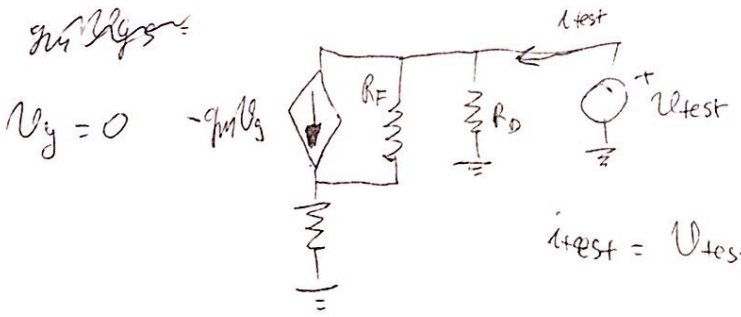
$2,05mA = (1+\beta) i_B + 0,6mA$

$i_E = -0,614mA$

$v_s = -\frac{R_s}{R_D} \cdot v_i$

$v_{gs} = v_g + \frac{R_s}{R_D} v_i$

$v_s - v_i = -\left(1 - \frac{R_s}{R_D}\right) v_i$



$v_g = 0$

$i_{test} = \frac{v_{test}}{R_D} - g_m v_s + \frac{v_{test} - v_s}{R_F}$

$i_{test} = v_{test}\left(\frac{1}{R_D} + \frac{-g_m + g_m R_F + \frac{R_F}{R_s}}{\frac{R_F}{R_s} + g_m R_F + 1} \right)$

R_{12L}^{-1}

$-g_m v_s + \frac{v_{test} - v_s}{R_F} = \frac{v_s}{R_s}$

$\frac{v_{test}}{R_F} = v_s\left(\frac{1}{R_s} + \frac{1}{R_F} + g_m \right)$

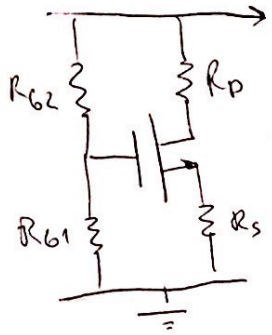
$v_{test} = v_s\left(\frac{R_F}{R_s} + g_m R_F + 1 \right)$

$v_s = \frac{v_{test}}{\frac{R_F}{R_s} + g_m R_F + 1}$

$v_{test} - v_s = v_{test}\left(1 - \frac{1}{\frac{R_F}{R_s} + g_m R_F + 1}\right) =$

$= v_{test} \cdot \frac{\frac{R_F}{R_s} + g_m R_F}{1 + g_m R_F + \frac{R_F}{R_s}}$

DC:



$$\frac{R_{G1}}{R_{G1}+R_{G2}} V_{DD} = 4V$$

$$V_G = 4V$$

$$V_S = I_D R_S$$

$$I_D = \frac{B}{2}\left(4 - I_D R_S - V_t\right)^2$$

$$2000 I_D = \left(3 - 500 I_D\right)^2$$

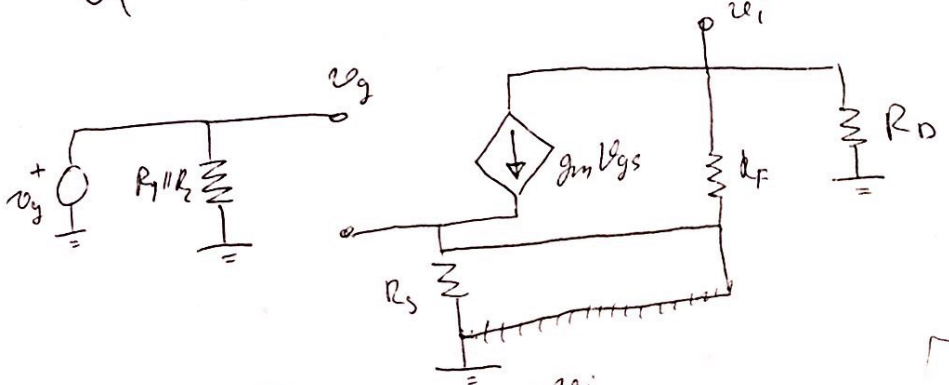
$$500^2 I_D^2 - 5000 I_D + 9 = 0$$

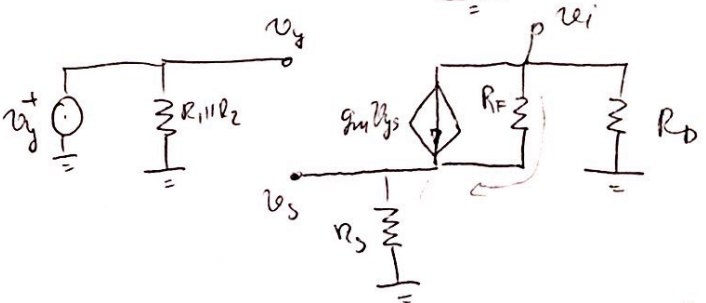
$$I_{D1,2} = \frac{5000 \pm 4000}{2 \cdot 500^2}$$

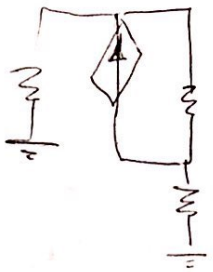
~~$I_{D1} = 18\,mA \quad V_{S1} = 9V \quad V_{D1}$~~

$$I_{D2} = 2mA \quad V_{S2} = 1V$$

$$v_i = V_{DD} - R_D I_D = 12 - 4 = 8V$$





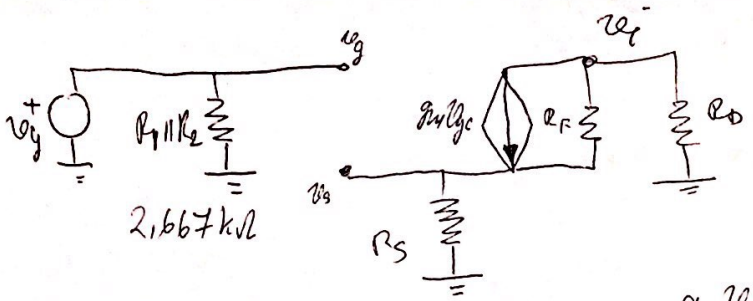


$$g_m v_{gs} + \frac{v_i - v_S}{R_F} - \frac{v_S}{R_S} = 0 \qquad -g_m v_{gs} - \frac{v_i - v_S}{R_F} - \frac{v_i}{R_D} = 0$$

$$\frac{v_i - v_S}{R_F} - \frac{v_S}{R_S} - \frac{v_i - v_S}{R_F} - \frac{v_i}{R_D} = 0 \qquad \boxed{v_S = -\frac{R_S}{R_D} v_i}$$

$$\frac{v_i - v_S - v_i + v_S}{R_F} - \frac{v_S}{R_S} - \frac{v_i}{R_D} = 0$$

$$v_{gs} = \boxed{v_g + \frac{R_S}{R_D} v_i}$$



$$g_m v_{gs} + \frac{v_i - v_s}{R_F} - \frac{v_s}{R_s} = 0$$

$$\frac{v_i - v_s}{R_F} + g_m v_{gs} = \frac{v_s}{R_s}$$

$$-g_m v_{gs} + \frac{v_s - v_i}{R_F} - \frac{v_i}{R_D} = 0$$

$$-\frac{v_i}{R_D} = \frac{v_s}{R_s} \qquad \boxed{v_i = -\frac{R_D}{R_s} v_s}$$

$$\frac{v_s (R_s + R_D)}{R_s R_F} = -\frac{v_s \frac{R_D}{R_s}}{R_D} + g_m v_g - g_m v_s$$

$$v_s \cdot \frac{R_s + R_D}{R_s R_F} + v_s \frac{1}{R_s} + g_m v_s = g_m v_g$$

$$v_s \left(\frac{R_s + R_D}{R_s R_F} + \frac{1}{R_s} + g_m \right) = g_m v_g$$

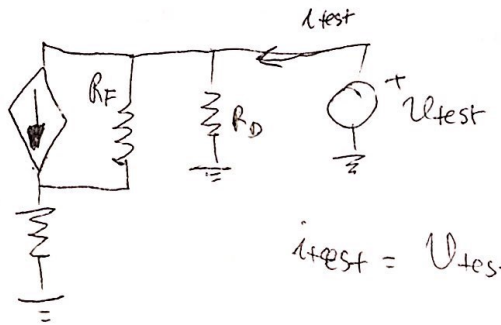
$$v_s = \frac{g_m}{\frac{R_s + R_D}{R_s R_F} + \frac{1}{R_s} + g_m} v_g \qquad v_i = \frac{-R_D g_m}{R_s \cdot \frac{R_s}{R_s R_F} + R_s \cdot \frac{R_D}{R_s R_F} + \frac{R_s}{R_s} + g_m R_s} =$$

$$= -\frac{g_m}{\frac{R_s}{R_D R_F} + \frac{1}{R_F} + \frac{1}{R_D} + g_m \frac{R_s}{R_D}} v_g$$

$$a = -1{,}231$$

$$v_s = -\frac{R_s}{R_D} \cdot v_i$$

$$v_{gs} = v_g + \frac{R_s}{R_D} v_i \qquad v_s - v_i = -\left(1 + \frac{R_s}{R_D}\right) v_i$$



$v_g = 0 \qquad -g_m v_g$

$$i_{test} = \frac{v_{test}}{R_D} - g_m v_g + \frac{v_{test} - v_s}{R_F}$$

$$i_{test} = v_{test}\left(\frac{1}{R_D} + \frac{-g_m + g_m R_F \parallel \frac{R_F}{R_s}}{\frac{R_F}{R_s} + g_m R_F + 1} \right)$$

R_{12L}^{-1}

$$-g_m v_s + \frac{v_{test} - v_s}{R_F} = \frac{v_s}{R_s}$$

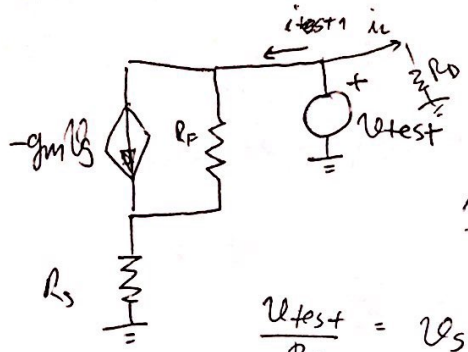
$$\frac{v_{test}}{R_F} = v_s\left(\frac{1}{R_s} + \frac{1}{R_F} + g_m \right)$$

$$v_{test} = v_s\left(\frac{R_F}{R_s} + g_m R_F + 1 \right)$$

$$v_s = \frac{v_{test}}{\frac{R_F}{R_s} + g_m R_F + 1}$$

$$v_{test} - v_s = v_{test}\left(1 - \frac{1}{\frac{R_F}{R_s} + g_m R_F + 1}\right) =$$

$$= v_{test} \cdot \frac{\frac{R_F}{R_s} + g_m R_F}{1 + g_m R_F + \frac{R_F}{R_s}}$$



$$\frac{v_{test} - v_S}{R_F} - g_m v_S + \frac{v_{test}}{R_D} = i_{test}$$

$$\frac{v_{test} - v_S}{R_F} - g_m v_S = \frac{v_S}{R_S}$$

$$\frac{v_{test}}{R_F} = v_S \left(\frac{1}{R_F} + \frac{1}{R_S} + g_m \right)$$

$$v_{test} = v_S \left(1 + \frac{R_F}{R_S} + g_m R_F \right)$$

$$v_S = \frac{v_{test}}{1 + g_m R_F + \frac{R_F}{R_S}}$$

$$v_{test} - v_{test} \left(1 - \frac{1}{1 + g_m R_F + \frac{R_F}{R_S}} \right) - \frac{g_m v_{test}}{1 + g_m R_F + \frac{R_F}{R_S}} = i_{test}$$

$$v_{test} \left(\frac{1}{R_D} + \frac{g_m R_F + \frac{R_F}{R_S} - g_m R_F}{R_F \left(1 + g_m R_F + \frac{R_F}{R_S} \right)} \right) = i_{test}$$

$$R_{IZL} = \left(\frac{1}{R_D} + R_S \left(1 + g_m R_F + \frac{R_F}{R_S} \right) \right)^{-1} = \left(R_F + R_S + g_m R_F R_S \right) \| R_D = 1{,}38\,k\Omega$$

$$R_{IZLL} = 1{,}38\,k\Omega = R_{IZL} \| R_D$$