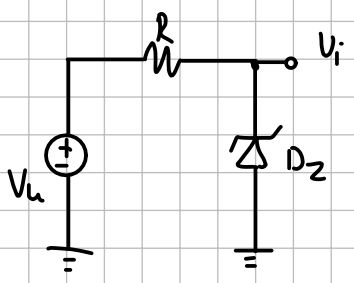
Зенер диода:



$V_i\ (V_u) = ?$

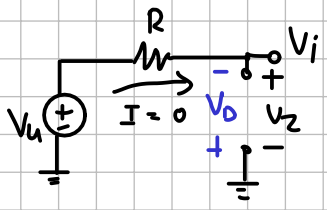
$-10V \le V_u \le 10V$

$R = 1k\Omega$

$V_{Z0} = 5V$

$V_{D0} = 0.6V$

1° D_Z - OFF



$V_i = V_u$

$V_Z = V_i = V_u$

$-0.6V \le V_Z \le V_{Z0} = 5V \quad \Rightarrow \quad -0.6V \le V_u \le 5V$

$-5V \le V_D \le 0.6V$

$V_u \nearrow 5V \Rightarrow D_Z$ улази у пробој

$V_u \swarrow -0.6V \Rightarrow D_Z$ директно води

Zadaci

1. Za diodno kolo sa Sl. 1 odrediti i nacrtati zavisnost:

a) izlaznog napona, V_i, i

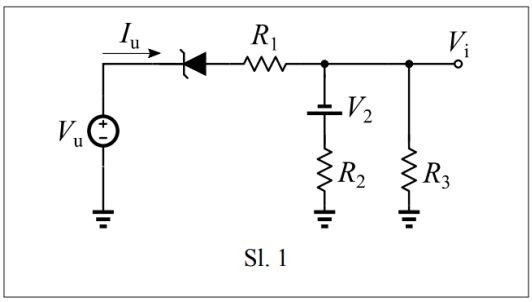
b) ulazne struje, I_u, u funkciji ulaznog napona V_u.

Poznato je:

R_1=1kΩ, R_2=R_3=2kΩ, V_2=6V i $-10V \le V_u \le 10V$.

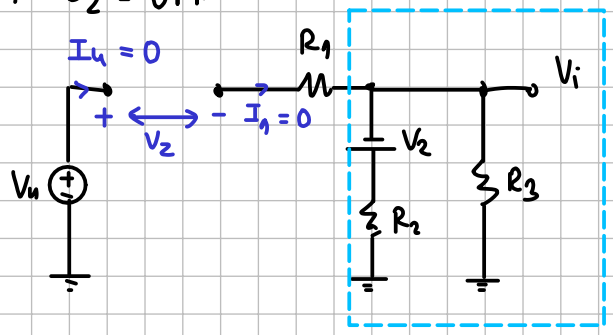
Parametri modela diode su:

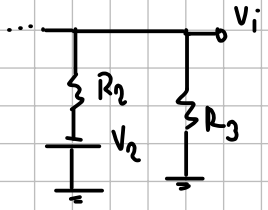
V_{D0}=0.6V, r_d=0Ω, V_{Z0}=6V, r_z=0Ω.



Sl. 1

1° D_2 - OFF





$$V_i = \frac{R_3}{R_3 + R_2} \cdot (-V_2)$$

$$V_i = -\frac{1}{2} V_2 = -3V$$

$I_u = 0$

$-V_{D0} \le V_2 \le V_{z0}$

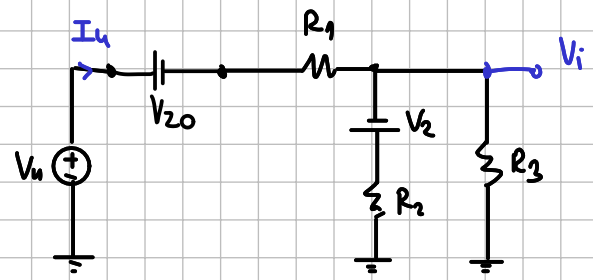
$V_2 = V_u - V_i = V_u + 3V$

$-0.6V \le V_u + 3V \le 6V \quad / -3V$

$-3.6V \le V_u \le 3V \Rightarrow$ $V_u \searrow -3.6V \Rightarrow$ директно вођење

$V_u \nearrow 3V \Rightarrow$ пробој

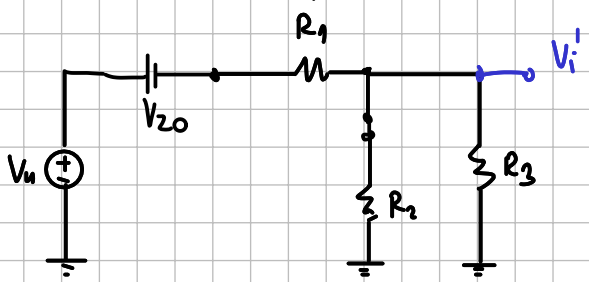
2° D_2 - B.D. $V_u \ge 3V$



$$I_u = \frac{V_u - V_{z0} - V_i}{R_1}$$

Суперпозиција:

1° V_u, V_{z0} - ON, V_2 - OFF

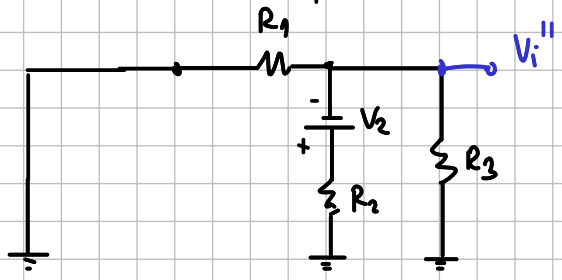


$$V_i' = \frac{R_2 \parallel R_3}{R_1 + R_2 \parallel R_3} \cdot (V_u - V_{z0})$$

$$= \frac{1k\Omega}{1k\Omega + 1k\Omega} \cdot (V_u - 6V)$$

$$= \frac{1}{2}(V_u - 6V) = \frac{1}{2} V_u - 3V$$

2° V_u, V_{Z0} - OFF, V_2 - ON



$$R_1 \| R_3 = \frac{R_1 \cdot R_3}{R_1 + R_3} = \frac{1k\Omega \cdot 2k\Omega}{3k\Omega} = \frac{2}{3}k\Omega$$

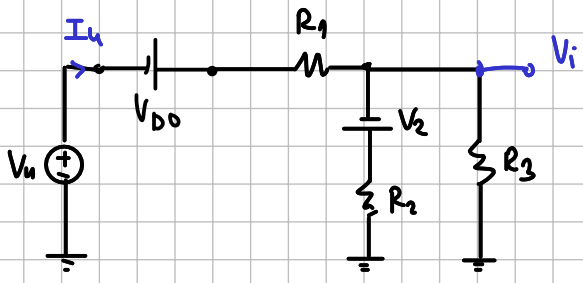
$$V_i'' = \frac{R_1 \| R_3}{R_2 + R_1 \| R_3} \cdot (-V_2) = \frac{\frac{2}{3}k\Omega}{2k\Omega + \frac{2}{3}k\Omega} \cdot (-6)V$$

$$= \frac{\frac{2}{3}}{\frac{8}{3}} \cdot (-6)V = -\frac{6}{4}V = -1.5V$$

$$V_i = V_i' + V_i'' = \frac{1}{2}V_u - 3V - 1.5V = \frac{1}{2}V_u - 4.5V$$

$$I_u = \frac{V_u - V_{Z0} - V_i}{R_1} = \frac{V_u - 6V - \left(\frac{1}{2}V_u - 4.5V\right)}{1k\Omega} = \frac{\frac{1}{2}V_u - 1.5V}{1k\Omega} = \frac{1}{2}mS \cdot V_u - 1.5mA$$

3° D_2 - ON, $V_u \leq -3.6V$



Исто коло као у случају пробоја, само се V_{Z0} променило у $-V_{DD}$.

Важе исти изрази за V_i и I_u, само уместо V_{Z0} пишемо $-V_{DD}$.

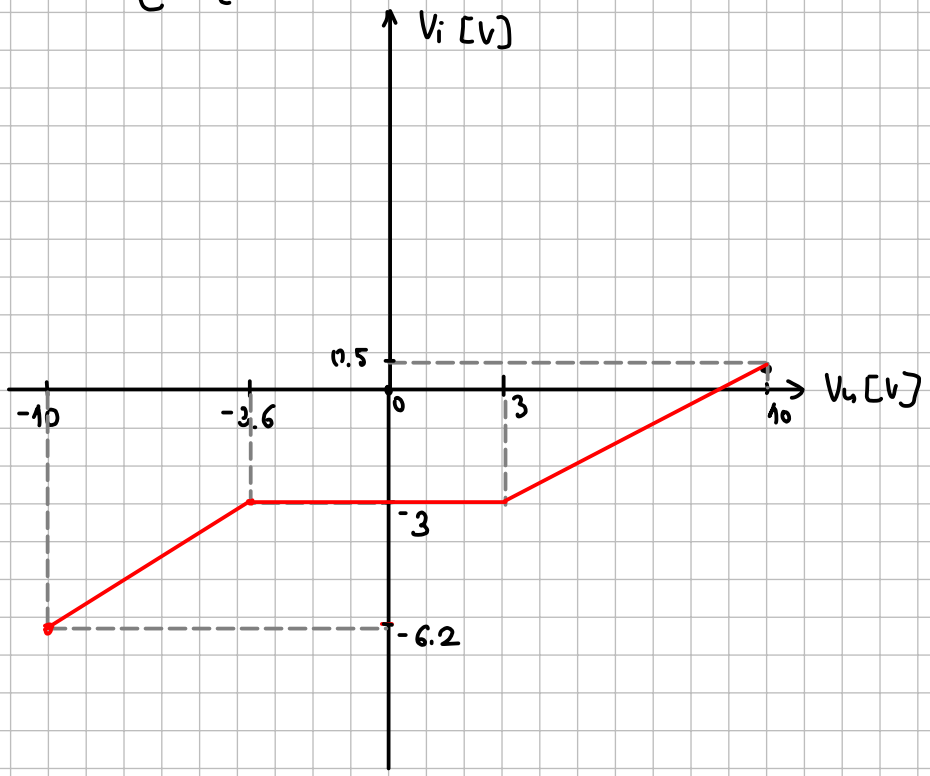
$$V_i' = \frac{R_2 \| R_3}{R_1 + R_2 \| R_3} \cdot (V_u + V_{DD}) = \frac{1}{2}(V_u + 0.6V) = \frac{1}{2}V_u + 0.3V$$

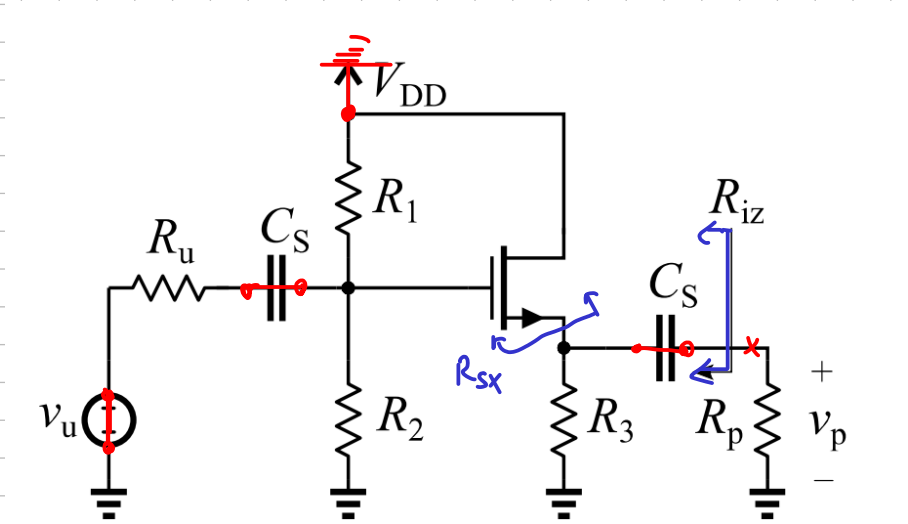
$$V_i'' = -1.5V$$

$$V_i = V_i' + V_i'' = \frac{1}{2}V_u - 1.2V$$

$$I_u = \frac{V_u + V_{DD} - V_i}{R_1} = \frac{V_u + 0.6V - \frac{1}{2}V_u + 1.2V}{1k\Omega} = \frac{\frac{1}{2}V_u + 1.8V}{1k\Omega} = \frac{1}{2}mS \cdot V_u + 1.8mA$$

$$V_i = \begin{cases} \frac{1}{2}V_u - 1.2V, & V_u \leq -3.6V \\ -3V, & -3.6V \leq V_u \leq 3V \\ \frac{1}{2}V_u - 4.5V, & V_u \geq 3V \end{cases}$$

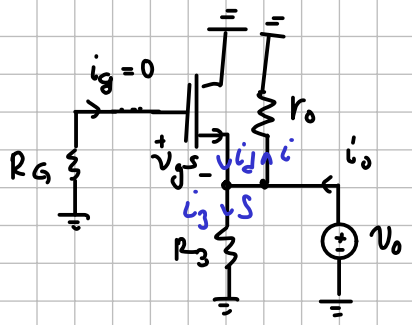




$$R_{iz} = R_3 \parallel R_{sx}$$

$$R_{sx} = \frac{r_o + 0}{\mu + 1} \qquad \mu = g_m r_o$$

$$R_{iz} = R_3 \parallel \frac{r_o}{\mu + 1}$$



$$R_G = R_1 \parallel R_2 \parallel R_4$$

$$v_o + v_{gs} - R_G \cdot i_g = 0 \quad \Rightarrow \quad v_{gs} = -v_o$$

S: $\quad i_o + i_d = i + i_3$

$$i_o + g_m v_{gs} = \frac{v_o}{r_o} + \frac{v_o}{R_3}$$

$$i_o = g_m v_o + \frac{v_o}{r_o} + \frac{v_o}{R_3}$$

$$R_1 \parallel R_2 = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}}$$

$$R_{iz} = \frac{v_o}{i_o} = \frac{1}{g_m + \frac{1}{r_o} + \frac{1}{R_3}} = \frac{1}{\frac{g_m r_o + 1}{r_o} + \frac{1}{R_3}}$$

$$= \frac{r_o}{g_m r_o + 1} \parallel R_3 = \frac{r_o}{\mu + 1} \parallel R_3$$