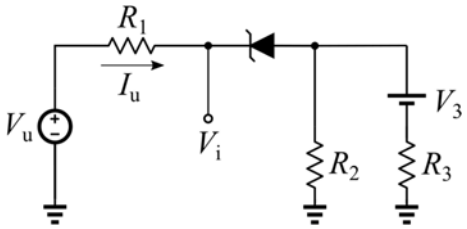
Elektronski fakultet u Nišu
Katedra za Elektroniku
Šifra: OEE3O01, OEM3O01, OET3O01, OEU3O02

Datum: 18. Septembar 2023.

OSNOVI ELEKTRONIKE

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.
Ulazni napon se kreće u opsegu od –15V do 15V.
Poznato je:
$R_1=R_2=R_3=1\text{k}\Omega$, $V_3=1\text{V}$
Parametri modela Zener diode su:
$V_{D0}=0.8\text{V}$, $r_d=0\Omega$, $V_{Z0}=3.1\text{V}$, $r_z=0\Omega$.

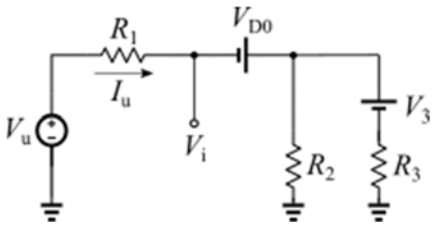


Sl. 1

Dioda vodi u direktnom smeru za $-15V \le V_u < 0.3V$ (5%)

$$V_i = \frac{R_3||R_2}{R_3||R_2+R_1}V_u + \frac{R_1||R_2}{R_1||R_2+R_3}V_3 + \frac{R_1}{R_2||R_3+R_1}(-V_{D0}) = \frac{1}{3}V_u - 0.2[V] \quad (5\%)$$

$$I_u = \frac{1}{R_1}(V_u - V_i) = \frac{2}{3}V_u + 0.2[mA] \quad (5\%)$$

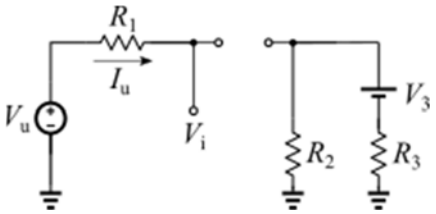


(5%)

Dioda ne vodi za $-0.3V \le V_u < 3.6V$, (5%)

$V_i = V_u[V]$ (5%)

$I_u = 0[mA]$ (5%)

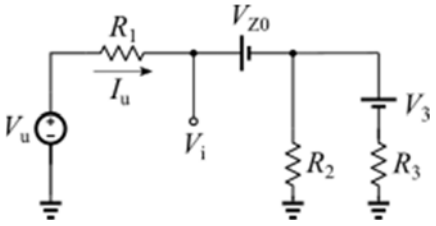


(5%)

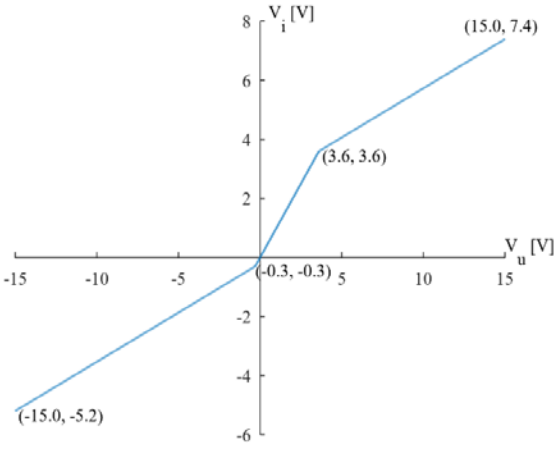
Dioda vodi u proboju za $3.6V \le V_u \le 15V$, (5%)

$$V_i = \frac{R_3||R_2}{R_3||R_2+R_1}V_u + \frac{R_1||R_2}{R_1||R_2+R_3}V_3 + \frac{R_1}{R_2||R_3+R_1}V_{Z0} = \frac{1}{3}V_u + 2.4[V] \quad (5\%)$$

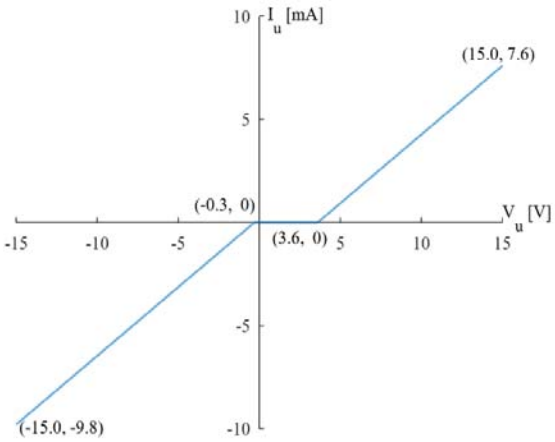
$$I_u = \frac{1}{R_1}(V_u - V_i) = \frac{2}{3}V_u - 2.4[mA] \quad (5\%)$$



(5%)


V_i [V]
8
6
4
2
-2
-4
-6
-15
-10
-5
5
10
15
V_u [V]
(15.0, 7.4)
(3.6, 3.6)
(-0.3, -0.3)
(-15.0, -5.2)

20%


I_u [mA]
10
5
-5
-10
-15
-10
-5
5
10
15
V_u [V]
(15.0, 7.6)
(-0.3, 0)
(3.6, 0)
(-15.0, -9.8)

20%

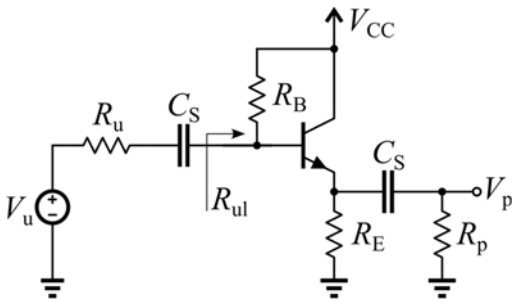
2. Za pojačavač sa Sl. 2 odrediti:

a) jednosmerni napon na emitoru tranzistora, V_E,
b) naponsko pojačanje, $A_n=v_p/v_u$ i
c) ulaznu otpornost, R_{ul}.

Poznato je:
R_B=100kΩ, R_E=1kΩ, R_u=1kΩ, R_p=10kΩ,
V_T=26mV, V_{CC}=12V.

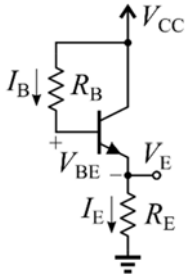
Parametri tranzistora su:
β=100, V_{BE}=0.7V.

Smatrati da su kapacitivnosti sprežnih kondenzatora, C_S, izuzetno velike.



Sl. 2

a)



(Šema: 5%)

$$V_{CC} = R_B I_B + V_{BE} + R_E I_E$$

$$I_B = \frac{V_{CC} - V_{BE}}{R_B + (1+\beta)R_E} = 56.22\mu A \quad (5\%)$$

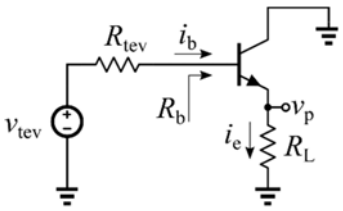
$$I_E = (1+\beta) I_B = 5.68mA$$
$$V_E = R_E I_E = 5.68V \quad (5\%)$$

b)

$$I_C = \beta I_B = 5.62mA$$

$$g_m = \frac{I_C}{V_T} = 216.15mS \quad (5\%)$$

$$r_\pi = \frac{\beta}{g_m} = \frac{V_T}{I_B} = 462.47\Omega \quad (5\%)$$



(Šema: 5%)

$$R_{tev} = R_B \parallel R_u = 990.1\Omega \quad (5\%)$$

$$v_{tev} = \frac{R_B}{R_B + R_u} v_u \quad (5\%)$$

$$R_L = R_E \parallel R_p = 909.09\Omega \quad (5\%)$$

$$R_b = r_\pi + (1+\beta) R_L = 92.28k\Omega \quad (10\%)$$

$$v_p = R_L i_e \quad (5\%)$$

$$i_e = \beta i_b + i_b = (\beta + 1) i_b \quad (5\%)$$

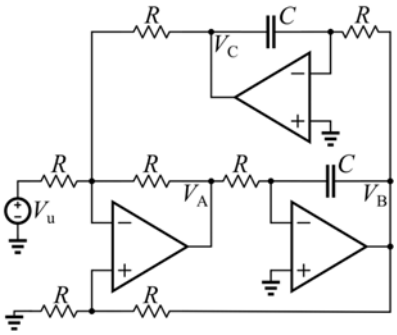
$$v_{tev} = (R_{tev} + R_b) i_b \quad (10\%)$$

$$A_n = \frac{v_p}{i_e} \cdot \frac{i_e}{i_b} \cdot \frac{i_b}{v_{tev}} \cdot \frac{v_{tev}}{v_u} = R_L \cdot (1+\beta) \cdot \frac{1}{R_{tev} + R_b} \cdot \frac{R_B}{R_B + R_u} = 0.975 \quad (10\%)$$

c) $R_{ul} = R_B \parallel R_b = 48k\Omega \quad (15\%)$

3. Za filtarsko kolo sa Sl. 3 odrediti:
a) Prenosnu funkciju $H_A(s)=V_A/V_u$,
b) Prenosnu funkciju $H_B(s)=V_B/V_u$,
c) Prenosnu funkciju $H_C(s)=V_C/V_u$ i
d) Tipove filtara realizovanih prenosnim funkcijama H_A, H_B i H_C.

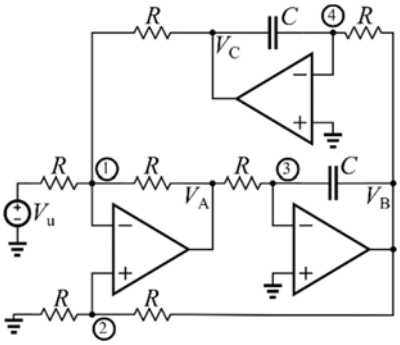
Poznato je:
R=1kΩ, C=10nF.
Operacioni pojačavači su idealni.



Sl. 3

Neka je $\tau = RC = 10\mu s$

Za ulazne priključke operacionih pojačavača važi:
$V_1 = V_2$ (5%)
$V_3 = 0$ (5%)
$V_4 = 0$ (5%)



Jednačine čvorova 1, 2, 3 i 4 su (10% po jednačini):

$$\frac{V_1 - V_u}{R} + \frac{V_1 - V_A}{R} + \frac{V_1 - V_C}{R} = 0 \;/\cdot R \quad \Rightarrow \quad 3V_1 - V_A - V_C = V_u$$

$$\frac{V_2}{R} + \frac{V_2 - V_B}{R} = 0 \;/\cdot R \quad \Rightarrow \quad 2V_1 - V_B = 0$$

$$\frac{V_3 - V_A}{R} + sC(V_3 - V_B) = 0 \;/\cdot R \quad \Rightarrow \quad V_A + s\tau V_B = 0$$

$$\frac{V_4 - V_B}{R} + sC(V_4 - V_C) = 0 \;/\cdot R \quad \Rightarrow \quad V_B + s\tau V_C = 0$$

a) Rešavanjem sistema po V_A, dobija se:

$$H_A(s) = \frac{V_A}{V_u} = -\frac{s^2\tau^2}{s^2\tau^2 + \frac{3s\tau}{2} + 1} = -\frac{\frac{s^2}{10^{10}}}{\frac{s^2}{10^{10}} + \frac{3s}{2\cdot 10^5} + 1} \quad (10\%)$$

b)

$$V_A + s\tau V_B = 0 \Rightarrow \frac{V_B}{V_A} = -\frac{1}{s\tau}$$

$$H_B(s) = \frac{V_B}{V_u} = \frac{V_B}{V_A}\cdot\frac{V_A}{V_u} = -\frac{H_A(s)}{s\tau} = \frac{s\tau}{s^2\tau^2 + \frac{3s\tau}{2} + 1} = \frac{\frac{s}{10^5}}{\frac{s^2}{10^{10}} + \frac{3s}{2\cdot 10^5} + 1} \quad (10\%)$$

c)

$$V_B + s\tau V_C = 0 \Rightarrow \frac{V_C}{V_B} = -\frac{1}{s\tau}$$

$$H_C(s) = \frac{V_C}{V_u} = \frac{V_C}{V_B}\cdot\frac{V_B}{V_u} = -\frac{H_B(s)}{s\tau} = -\frac{1}{s^2\tau^2 + \frac{3s\tau}{2} + 1} = -\frac{1}{\frac{s^2}{10^{10}} + \frac{3s}{2\cdot 10^5} + 1} \quad (10\%)$$

d) Sve tri funkcije su funkcije drugog reda.

- H_A je filtar propusnik **visokih** učestanosti, zbog člana sa s^2 u brojiocu. (5%)
- H_B je filtar propusnik **opsega** učestanosti, zbog člana sa s u brojiocu. (5%)
- H_C je filtar propusnik **niskih** učestanosti, zbog konstante u brojiocu. (5%)

4. Za regulator sa Sl. 4 odrediti:

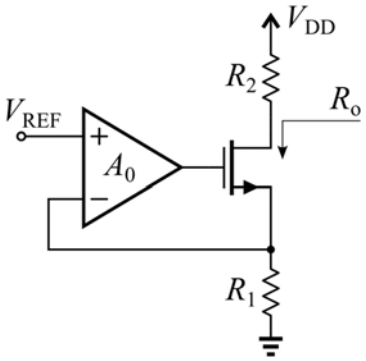
a) jednosmerni napon na gejtu tranzistora, V_G
b) parametre za male signale, g_m i r_0, i
c) izlaznu otpornost R_0.

Poznato je:
R_1=10kΩ, R_2=15kΩ, V_{REF}=1V i V_{DD}=3.3V.

Tranzistor ima sledeće parametre:
V_{TH}=0.35V, A=1.6mA/V^2, V_A=50V.

Operacioni pojačavač ima sledeće parametre:
A_0 =10^3 V/V, $R_{ul} \to \infty\Omega$, $R_{iz} \to 0\Omega$.

Za jednosmerni režim smatrati da $A_0 \to \infty$ V/V.



Sl. 4

a) i b)

(10%) $V_S = V_{REF} = 1\text{V}$

(10%) $I_D = \dfrac{V_S}{R_1} = 100\mu\text{A}$

(10%) $V_{ov} = \sqrt{\dfrac{I_D}{A}} = 250\text{mV}$

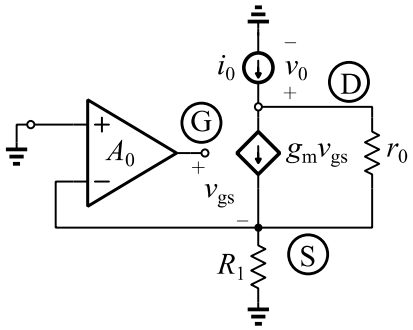
(5%) $g_m = 2AV_{ov} = 800\mu\text{S}$

(5%) $r_o = \dfrac{V_A}{I_D} = 500\text{k}\Omega$

(5%) $V_{GS} = V_{TH} + V_{ov} = 0.6\text{V}$

(5%) $V_G = V_{GS} + V_S = 1.6\text{V}$

c)



(10%) $i_0 = \dfrac{v_0 - v_s}{r_0} + g_m v_{gs}$

(10%) $i_0 = \dfrac{v_s}{R_1}$

(10%) $v_g = -A_0 v_s$

(10%) $R_0 = r_o + (1 + g_m r_o\,(1 + A_0))\,R_1 = 4.005\text{G}\Omega$

(Šema: 10%)