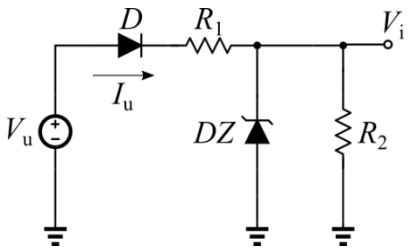
Elektronski fakultet u Nišu
Katedra za Elektroniku
Šifra: OEE3O01, OEM3O01, OET3O01, OEU3O02

Datum: 25. mart 2024.

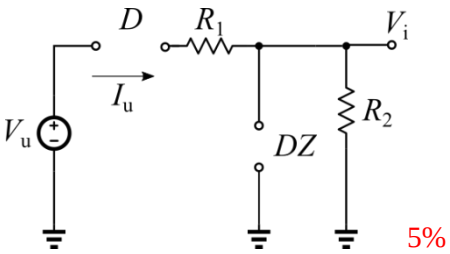
OSNOVI ELEKTRONIKE

Zadaci

1. Za diodno kolo sa Sl. 1 odrediti i nacrtati zavisnost:
a) Izlaznog napona, V_i, i
b) Struje I_u, u funkciji ulaznog napona V_u.
Poznato je:
$R_1 = R_2 = 1k\Omega$ i $-10V \leq V_u \leq 10V$.
Parametri modela dioda su:
$V_{D0} = 0.7V$, $r_d = 0\Omega$, $V_{Z0} = 3.3V$ i $r_z = 0\Omega$.



Sl. 1

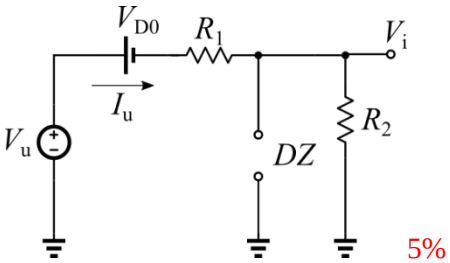


5%

Za $-10V \leq Vu \leq 0.7V$ diode D i DZ ne vode: 5%

$V_i = 0\ V$ 5%

$I_u = 0\ mA$ 5%

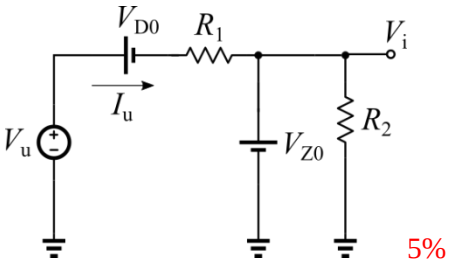


5%

Za $0.7V < Vu \leq 7.3V$ dioda D vodi i dioda DZ ne vodi: 5%

$V_i = \frac{R_2}{R_1+R_2}(V_u - V_{D0}) = \frac{1}{2}V_u - 0.35\ [V]$ 5%

$I_u = \frac{V_u - V_{D0} - V_i}{R_1} = \frac{1}{2}V_u - 0.35\ [mA]$ 5%

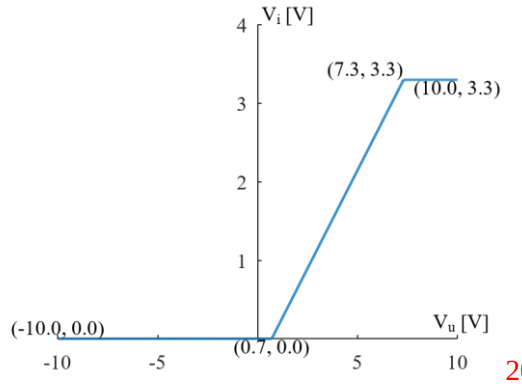


5%

Za $7.3V < Vu \leq 10V$ dioda D vodi i dioda DZ vodi inverzno: 5%

$V_i = V_{Z0} = 3.3V$ 5%

$I_u = \frac{V_u - V_{D0} - V_i}{R_1} = V_u - 4\ [mA]$ 5%



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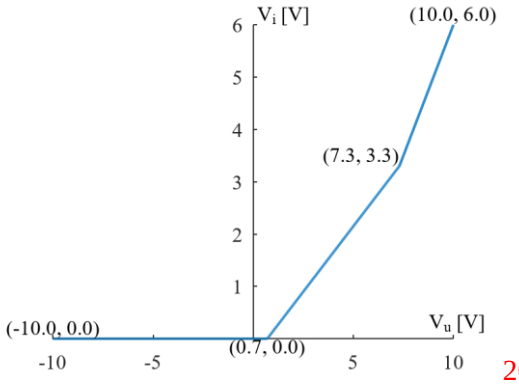

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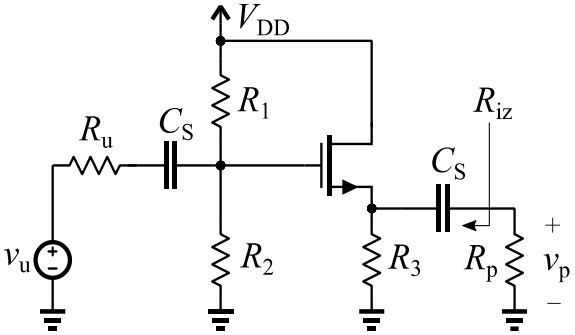
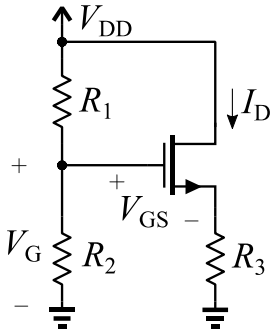
2. Za pojačavač sa Sl. 2 odrediti:
a) Parametre modela za male signale, g_m i r_0,
b) Naponsko pojačanje, $A_n=v_p/v_u$ i
c) Izlaznu otpornost, R_{iz}.
Poznato je:
R_1=100kΩ, R_2=400kΩ, R_3=1.5kΩ, R_u=100Ω, R_p=5kΩ i V_{DD}=5V.
Parametri tranzistora su:
A = 8mA/V^2, V_{TH}=0.5V i V_A=100V.
Smatrati da su kapacitivnosti sprežnih kondenzatora, C_S, izuzetno velike.



Sl. 2

a)



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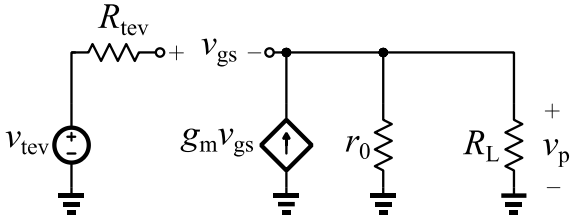
$$V_G = V_{GS} + I_D R_3$$
$$V_G - V_{TH} = V_{GS} - V_{TH} + A\left(V_{GS} - V_{TH}\right)^2 R_3$$
$$V_{ov} = V_{GS} - V_{TH}$$
$$AR_3 V_{ov}^2 + V_{ov} - \left(V_G - V_{TH}\right) = 0$$
$$V_{ov} = 0.5V \Rightarrow I_D = AV_{ov}^2 = 2mA$$

10%

$$g_m = 2AV_{ov} = 8mS,\ r_0 = \frac{V_A}{I_D} = 50k\Omega$$

10%

b)



$$R_g = R_1 || R_2 = 80k\Omega$$
$$R_{tev} = R_g || R_u = 99.875\Omega$$
$$v_{tev} = \frac{R_g}{R_g + R_u} v_u = 0.9988 v_u$$
$$R_L = R_3 || R_p = 1.154k\Omega$$

$$EQ1: v_{gs} = v_{tev} - v_p$$
$$EQ2: v_p \frac{1}{R_L || r_0} - g_m v_{gs} = 0$$

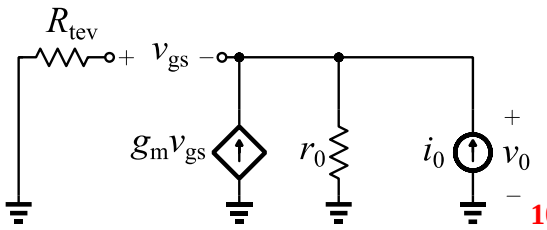
10%

20%

$$A_n = \frac{v_p}{v_{tev}} \times \frac{v_{tev}}{v_u} = \frac{g_m\left(R_L || r_0\right)}{1 + g_m\left(R_L || r_0\right)} \times \frac{R_g}{R_g + R_u} = 0.899 V/V$$

10%

c)



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$$EQ1: v_{gs} = -v_0$$

$$EQ1: -i_0 - g_m v_{gs} + v_0 \frac{1}{r_0} = 0$$

$$R_T = \frac{v_0}{i_0} = \frac{r_0}{1+\mu} = 124.69\Omega$$

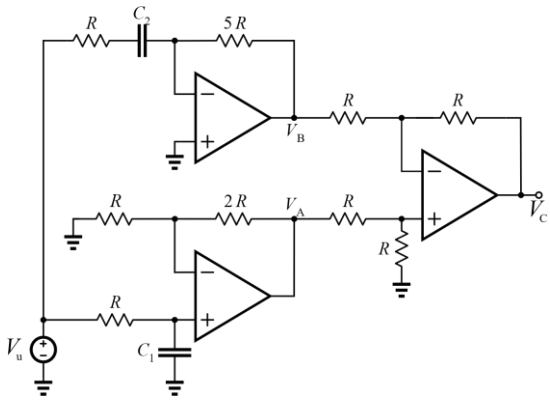
$$R_{iz} = R_T || R_3 = 115.119\Omega$$

20%

3. Za filtarsko kolo sa Sl. 3 odrediti:

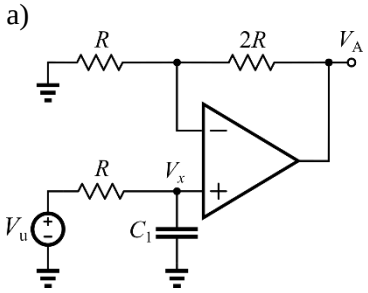
a) Prenosnu funkciju $H_A(s)=V_A/V_u$ i njen tip,
b) Prenosnu funkciju $H_B(s)=V_B/V_u$ i njen tip,
c) Prenosnu funkciju $H_C(s)=V_C/V_u$, i
d) Pojačanja funkcije $H_C(s)$ na niskim i visokim učestanostima.

Poznato je:
R=10kΩ, C_1=100pF i C_2=10nF.
Operacioni pojačavači su idealni.



Sl. 3

a)



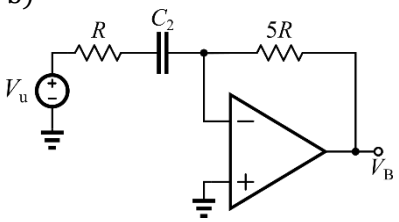
$$V_x = \frac{\frac{1}{sC_1}}{\frac{1}{sC_1}+R} V_u = \frac{1}{1+sRC_1} V_u$$

$$V_A = \left(1+\frac{2R}{R}\right) V_x = 3V_x = \frac{3}{1+sR_1C_1} V_u$$

$$H_A(s) = \frac{3}{1+sRC_1}$$

$H_A(s)$ - Propusnik niskih učestanosti (25 %)

b)



$$V_B = -\frac{5R}{R+\frac{1}{sC_2}} V_u = -5\frac{sRC_2}{1+sRC_2} V_u$$

$$H_B(s) = -5\frac{sRC_2}{1+sRC_2}$$

$H_B(s)$ - Propusnik visokih učestanosti (20 %)

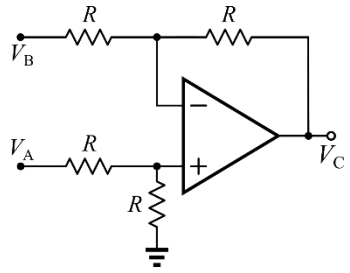
c)

Kolo za oduzimanje (diferencijalni pojačavač): (25 %)

$$V_C = \frac{R}{R+R}\left(1+\frac{R}{R}\right) V_A - \frac{R}{R} V_B = V_A - V_B$$

$$= \left(\frac{3}{1+sRC_1} + \frac{5sRC_2}{1+sRC_2}\right) V_u$$

$$= \frac{3(1+sRC_2) + 5sRC_2(1+sRC_1)}{(1+sRC_1)(1+sRC_2)} V_u$$



$$H_C(s) = \frac{5s^2R^2C_1C_2 + 8sRC_2 + 3}{s^2R^2C_1C_2 + sR(C_1 + C_2) + 1}$$

d)

Na niskim učestanostima: $A_0 = H_C(s \to 0) = 3$ (15 %)

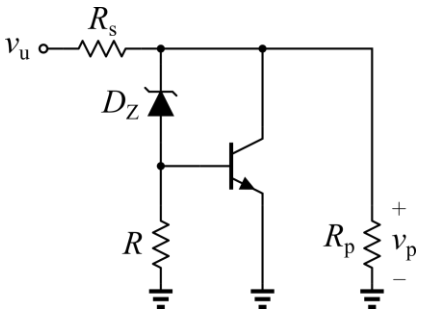
Na visokim učestanostima: $A_\infty = H_C(s \to \infty)$: (15 %)

$$A_\infty = \lim_{s\to\infty} \frac{5s^2R^2C_1C_2 + 8sRC_2 + 3}{s^2R^2C_1C_2 + sR(C_1 + C_2) + 1} = \lim_{s\to\infty} \frac{s^2\left(5R^2C_1C_2 + \frac{8RC_2}{s} + \frac{3}{s^2}\right)}{s^2\left(R^2C_1C_2 + \frac{R(C_1 + C_2)}{s} + \frac{1}{s^2}\right)} = 5$$

4. Za regulator sa Sl. 4 odrediti:

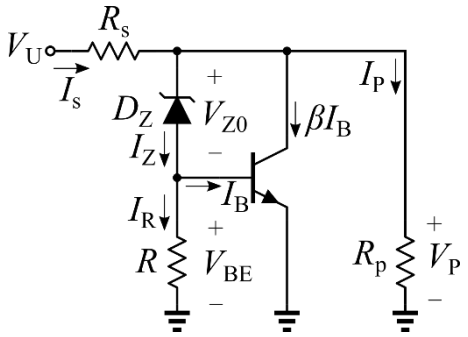
a) Jednosmernu vrednost izlaznog napona, V_P,
b) Parametre modela za male signale, g_m i r_π, i
c) Osetljivost regulatora, $S=v_p/v_u$.

Poznato je:
$R_s=R_p=500\Omega$, $R=100k\Omega$, $V_U=15V$ i $V_T=25mV$.
Parametri tranzistora su:
$\beta=100$ i $V_{BE}=0.7V$.
Parametri Zener diode su:
$V_{Z0}=6.2V$ i $r_z=15\Omega$.



Sl. 4

a) i b)



$$EQ1: V_P \approx V_{Z0} + V_{BE} = 6.9V$$

$$EQ2: \frac{V_U - V_P}{R_s} = I_B + \frac{V_{BE}}{R} + \beta I_B + \frac{V_P}{R_P}$$

$$I_B = \frac{1}{1+\beta}\left(\frac{V_U}{R_s} - \frac{V_{BE}}{R} - \frac{V_P}{R_s||R_p}\right) = 23.693$$

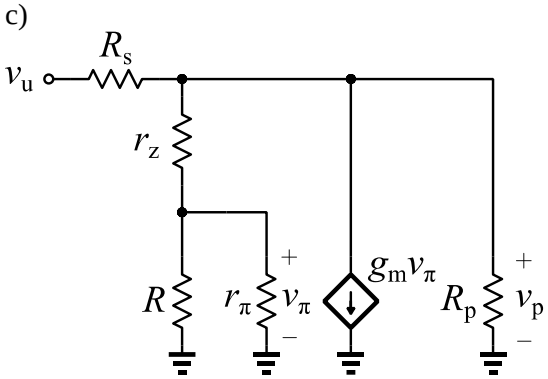
$$I_C = \beta I_B = 2.369mA$$

$$g_m = \frac{I_C}{V_T} = 94.772mS$$

$$r_\pi = \frac{\beta}{g_m} = \frac{V_T}{I_B} = 1.055k\Omega$$

Izraz za V_P - 15 %
Šema za DC – 10 %
Izraz za I_B – 15 %
Parametri – 5 % + 5 %

c)



$$EQ1: \frac{v_u - v_p}{R_s} = \frac{v_p - v_\pi}{r_z} + \frac{v_p}{R_p} + g_m v_\pi$$

$$EQ2: \frac{v_p - v_\pi}{r_z} = \frac{v_\pi}{R||r_\pi}$$

$$S = \frac{v_p}{v_u} = \frac{1}{1 + R_s\left(\frac{1}{R_p} + \frac{1+g_m(r_\pi||R)}{r_z + r_\pi||R}\right)} = 2.033 \times 10^{-2} V/V$$

Šema za AC – 10 %
Jednačine – 10 % + 10 %
Izraz za osetljivost – 20 %