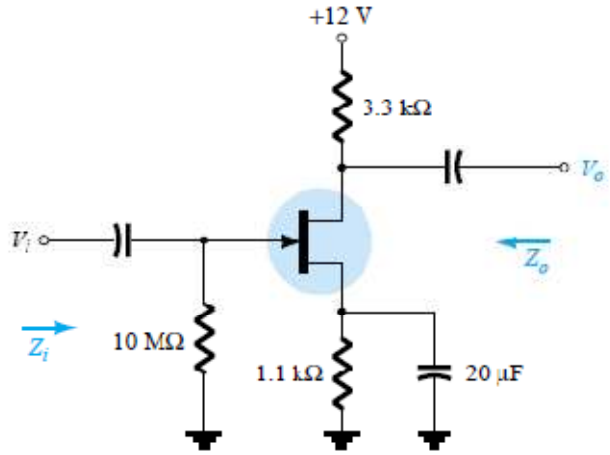
Soru 1.

Determine Z_i, Z_o, and A_v for the network if $y_{fs} = 3000\ \mu S$ and $y_{os} = 50\ \mu s$.



Çözüm 1.

$$g_m = y_{fs} = 3000\ \mu S = 3\ mS$$

$$r_d = \frac{1}{y_{os}} = \frac{1}{50\ \mu S} = 20\ k\Omega$$

$$Z_i = R_G = \mathbf{10\ M\Omega}$$

$$Z_o = r_d \,||\, R_D = 20\ k\Omega || \ 3.3\ k\Omega = \mathbf{2.83\ k\Omega}$$

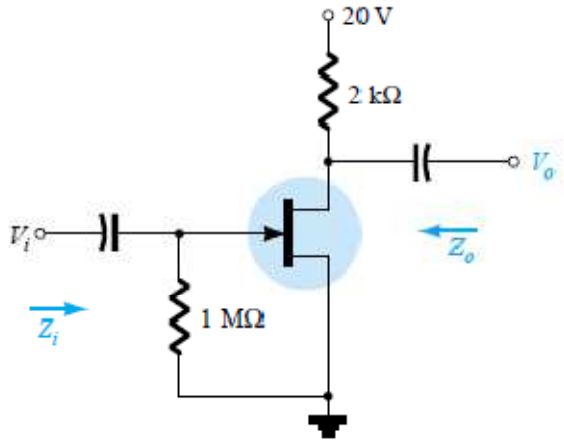
$$A_v = -g_m(r_d \,||\, R_D)$$

$$= -(3\ mS)(2.83\ k\Omega)$$

$$= \mathbf{-8.49}$$

Soru 2.

Determine Z_i, Z_o, and A_v for the network if $I_{DSS} = 6\ mA$, $V_P = -6\ V$, and $y_{os} = 40\ \mu S$.



Cevap 2.

$$V_{GS_Q} = 0\ V,\ g_m = g_{m0} = \frac{2I_{DSS}}{|V_P|} = \frac{2(6\ mA)}{6\ V}$$

$$= 2\ mS,\ r_d = \frac{1}{y_{os}} = \frac{1}{40\ \mu S} = 25\ k\Omega$$

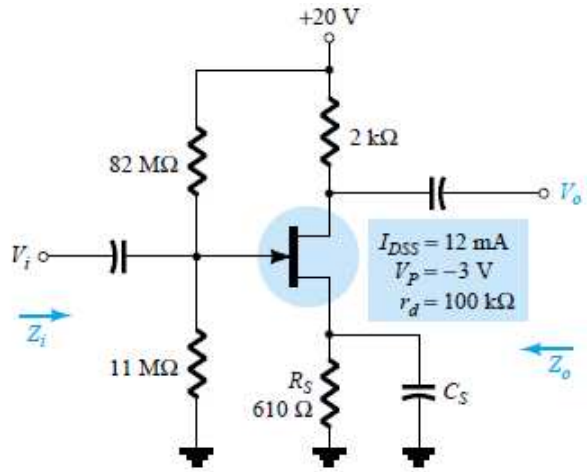
$$Z_i = \mathbf{1\ M\Omega}$$

$$Z_o = r_d \,||\, R_D = 25\ k\Omega \,||\, 2\ k\Omega = \mathbf{1.852\ k\Omega}$$

$$A_v = -g_m(r_d \,||\, R_D) = -(2\ mS)(1.852\ k\Omega) \cong \mathbf{-3.7}$$

Soru 3.

Determine Z_i, Z_o, and V_o for the network if $V_i = 20$ mV.



Cevap 3.

$$V_{GS_Q} = -0.95 \text{ V}$$

$$g_m = \frac{2I_{DSS}}{V_P}\left(1 - \frac{V_{GS_Q}}{V_P}\right)$$

$$= \frac{2(12 \text{ mA})}{3 \text{ V}}\left(1 - \frac{-0.95 \text{ V}}{-3 \text{ V}}\right)$$

$$= 5.47 \text{ mS}$$

$Z_i = 82 \text{ MΩ} \parallel 11 \text{ MΩ} = \mathbf{9.7\ MΩ}$

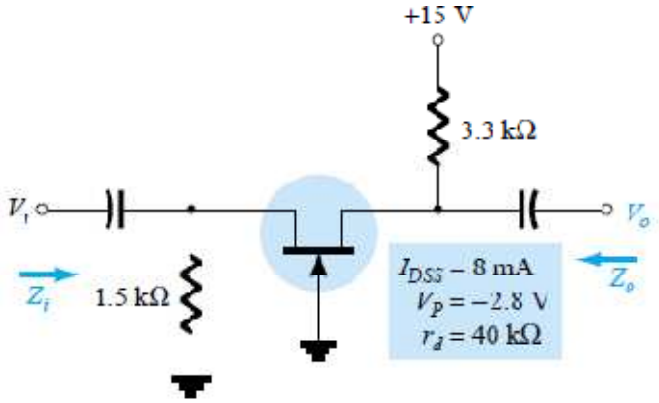
$Z_o = r_d \parallel R_D = 100 \text{ kΩ} \parallel 2 \text{ kΩ} = \mathbf{1.96\ kΩ}$

$A_v = -g_m(r_d \parallel R_D) = -(5.47 \text{ mS})(1.96 \text{ kΩ}) = \mathbf{-10.72}$

$V_o = A_v V_i = (-10.72)(20 \text{ mV}) = \mathbf{-214.4\ mV}$

Soru 4.

Determine Z_i, Z_o, and V_o for the network if $V_i = 0.1$ mV.



Cevap 4.

$$V_{GS_Q} = -2.85 \text{ V}, g_m = \frac{2I_{DSS}}{V_P}\left(1 - \frac{V_{GS_Q}}{V_P}\right) = \frac{2(9 \text{ mA})}{4.5 \text{ V}}\left(1 - \frac{-2.85 \text{ V}}{-4.5 \text{ V}}\right) = 1.47 \text{ mS}$$

$Z_i = R_G = \mathbf{10\ MΩ}$

$Z_o = r_d \parallel R_S \parallel 1/g_m = 40 \text{ kΩ} \parallel 2.2 \text{ kΩ} \parallel \underbrace{1/1.47 \text{ mS}}_{680.27\ Ω} = \mathbf{512.9\ Ω}$

$$A_v = \frac{g_m(r_d \parallel R_S)}{1 + g_m(r_d \parallel R_S)} = \frac{(1.47 \text{ mS})(40 \text{ kΩ} \parallel 2.2 \text{ kΩ})}{1 + (1.47 \text{ mS})(40 \text{ kΩ} \parallel 2.2 \text{ kΩ})} = \frac{3.065}{1 + 3.065}$$

$= \mathbf{0.754}$

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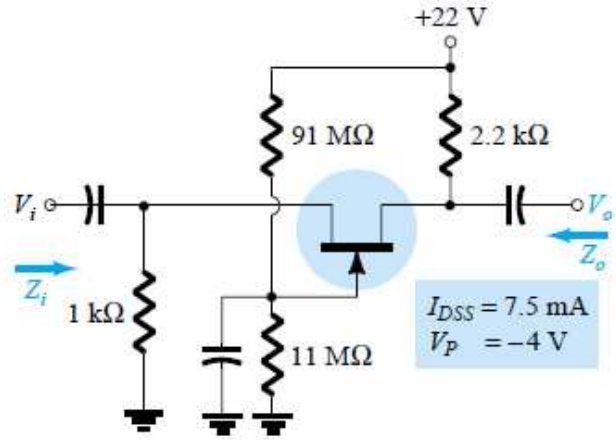
Soru 5.

Determine Z_i, Z_o, and A_v for the network if $r_d = 33\ \text{k}\Omega$.

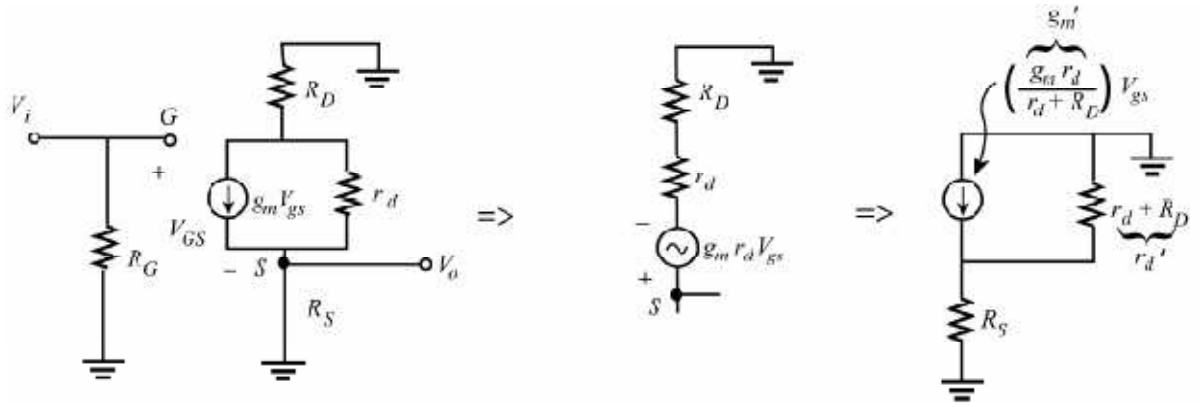


Cevap 5.

$$V_{GS_Q} = -3.8\ \text{V}$$

$$g_m = \frac{2I_{DSS}}{V_P}\left(1 - \frac{V_{GS_Q}}{V_P}\right) =$$

$$\frac{2(6\ \text{mA})}{6\ \text{V}}\left(1 - \frac{-3.8\ \text{V}}{-6\ \text{V}}\right) = 0.733\ \text{mS}$$



The network now has the format examined in the text and

$$Z_i = R_G = 10\ \text{M}\Omega \qquad r_d' = r_d + R_D = 30\ \text{k}\Omega + 3.3\ \text{k}\Omega = 33.3\ \text{k}\Omega$$

$$Z_o = r_d' \,\|\, R_S \,\|\, 1/g_m' = \qquad g_m' = \frac{g_m r_d}{r_d + R_D} = \frac{(0.733\ \text{mS})(30\ \text{k}\Omega)}{30\ \text{k}\Omega + 3.3\ \text{k}\Omega} = \frac{21.99}{33.3\ \text{k}\Omega} = 0.66\ \text{mS}$$

$$= 33.3\ \text{k}\Omega \,\|\, 3.3\ \text{k}\Omega \,\|\, 1/0.66\ \text{mS}$$

$$= 3\ \text{k}\Omega \,\|\, 1.52\ \text{k}\Omega$$

$$\cong \mathbf{1\ k\Omega}$$

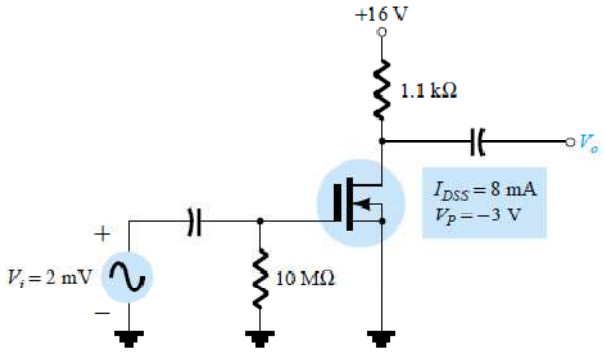
$$A_v = \frac{g_m'(r_d' \,\|\, R_S)}{1 + g_m'(r_d' \,\|\, R_S)} = \frac{0.66\ \text{mS}(3\ \text{k}\Omega)}{1 + 0.66\ \text{mS}(3\ \text{k}\Omega)} = \frac{1.98}{1 + 1.98} = \frac{1.98}{2.98}$$

$$= \mathbf{0.66}$$

Soru 6.

Determine V_o for the network if $y_{os} = 20\ \mu S$.

Cevap 6.



$$r_d = \frac{1}{y_{os}} = \frac{1}{20\ \mu S} = 50\ k\Omega,\ V_{GS_Q} = 0\ V$$

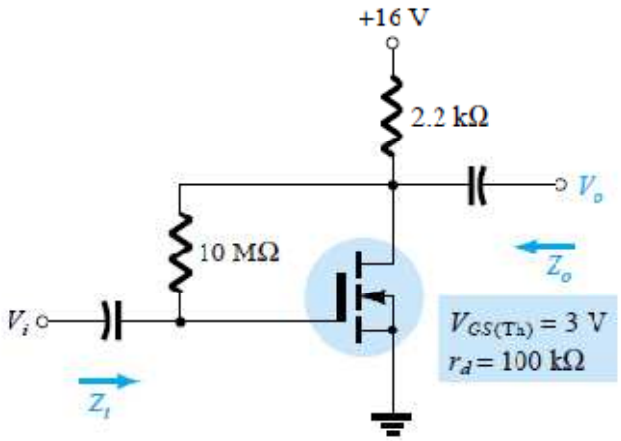
$$g_m = g_{m0} = \frac{2I_{DSS}}{V_P} = \frac{2(8\ mA)}{3} = 5.33\ mS$$

$$A_v = -g_m R_D = -(5.33\ mS)(1.1\ k\Omega) = -5.863$$

$$V_o = A_v V_i = (-5.863)(2\ mV) = \mathbf{11.73\ mV}$$

Soru 7.

Determine Z_i, Z_o, and A_v for the amplifier if $k = 0.3 \times 10^{-3}$.



Cevap 7.

$$V_{GS_Q} = 6.7\ V$$

$$g_m = 2k\left(V_{GS_Q} - V_T\right) = 2(0.3 \times 10^{-3})(6.7\ V - 3\ V) = 2.22\ mS$$

$$Z_i = \frac{R_F + r_d \| R_D}{1 + g_m(r_d \| R_D)} = \frac{10\ M\Omega + 100\ k\Omega \| 2.2\ k\Omega}{1 + (2.22\ mS)(100\ k\Omega \| 2.2\ k\Omega)}$$

$$= \frac{10\ M\Omega + 2.15\ k\Omega}{1 + 2.22\ mS(2.15\ k\Omega)} \cong \mathbf{1.73\ M\Omega}$$

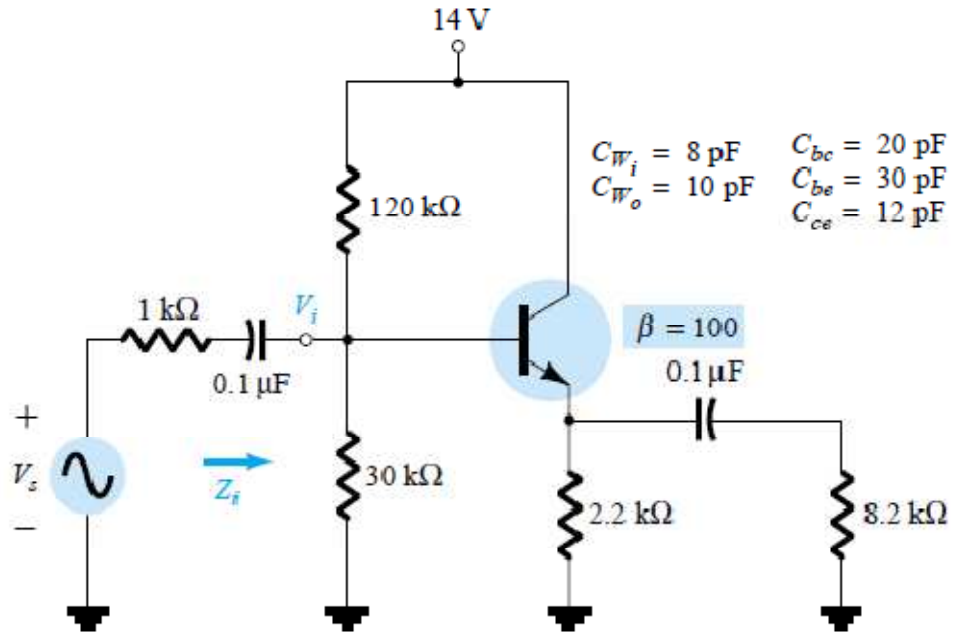
$$Z_o = R_F \| r_d \| R_D = 10\ M\Omega \| 100\ k\Omega \| 2.2\ k\Omega = \mathbf{2.15\ k\Omega}$$

$$A_v = -g_m(R_F \| r_d \| R_D) = -2.22\ mS(2.15\ k\Omega) = \mathbf{-4.77}$$

Soru 8.

For the network

(a) Determine r_e.
(b) Find $A_{v_{mid}} = V_o/V_i$.
(c) Calculate Z_i.
(d) Find $A_{v_{Smid}} = V_o/V_s$.
(e) Determine f_{L_S}, f_{L_C}, and f_{L_E}.
(f) Determine the low cutoff frequency.
(g) Sketch the asymptotes of the Bode plot defined by the cutoff frequencies of part (e).
(h) Sketch the low-frequency response for the amplifier using the results of part (f).



Cevap 8.

(a) $\beta R_E \geq 10R_2$

$(100)(2.2\ \text{k}\Omega) \geq 10(30\ \text{k}\Omega)$

$220\ \text{k}\Omega \not\geq 300\ \text{k}\Omega$ (No!)

$R_{Th} = R_1 \parallel R_2 = 120\ \text{k}\Omega \parallel 30\ \text{k}\Omega = 24\ \text{k}\Omega$

$$E_{Th} = \frac{30\ \text{k}\Omega(14\ \text{V})}{30\ \text{k}\Omega + 120\ \text{k}\Omega} = 2.8\ \text{V}$$

$$I_B = \frac{E_{Th} - V_{BE}}{R_{Th} + (\beta+1)R_E} = \frac{2.8\ \text{V} - 0.7\ \text{V}}{24\ \text{k}\Omega + 222.2\ \text{k}\Omega}$$

$= 8.53\ \mu\text{A}$

$I_E = (\beta+1)I_B = (101)(8.53\ \mu\text{A})$

$= 0.86\ \text{mA}$

$$r_e = \frac{26\ \text{mV}}{I_E} = \frac{26\ \text{mV}}{0.86\ \text{mA}} = \mathbf{30.23\ \Omega}$$

(b) $$A_{v_{mid}} = \frac{R_E \| R_L}{r_e + R_E \| R_L}$$

$$= \frac{2.2\ \text{k}\Omega \| 8.2\ \text{k}\Omega}{30.23\ \Omega + 2.2\ \text{k}\Omega \| 8.2\ \text{k}\Omega}$$

$$= \mathbf{0.983}$$

(c) $$Z_i = R_1 \| R_2 \| \beta(r_e + R'_E) \qquad R'_E = R_E \| R_L = 2.2\ \text{k}\Omega \| 8.2\ \text{k}\Omega = 1.735\ \text{k}\Omega$$

$$= 120\ \text{k}\Omega \| 30\ \text{k}\Omega \| (100)(30.23\ \Omega + 1.735\ \text{k}\Omega)$$

$$= \mathbf{21.13\ k\Omega}$$

(d) $$A_{v_s} = \frac{V_o}{V_s} = \frac{V_o}{V_i} \cdot \frac{V_i}{V_s} \qquad \frac{V_i}{V_s} = \frac{Z_i}{Z_i + R_s} = \frac{21.13\ \text{k}\Omega}{21.13\ \text{k}\Omega + 1\ \text{k}\Omega} = 0.955$$

(e) $$f_{L_S} = \frac{1}{2\pi(R_s + R_i)C_s}$$

$$= \frac{1}{2\pi(1\ \text{k}\Omega + 21.13\ \text{k}\Omega)(0.1\ \mu\text{F})}$$

$$= \mathbf{71.92\ Hz}$$

$$f_{L_C} = \frac{1}{2\pi(R_o + R_L)C_C}$$

$$R_o = R_E \| \left(\frac{R'_s}{\beta} + r_e \right)$$

$$= (2.2\ \text{k}\Omega) \| \left(\frac{0.96\ \text{k}\Omega}{100} + 30.23\ \Omega \right)$$

$$= 39.12\ \Omega$$

$$R'_s = R_s \| R_1 \| R_2$$

$$= 1\ \text{k}\Omega \| 120\ \text{k}\Omega \| 30\ \text{k}\Omega$$

$$= 0.96\ \text{k}\Omega$$

$$f_{L_C} = \frac{1}{2\pi(39.12\ \Omega + 8.2\ \text{k}\Omega)(0.1\ \mu\text{F})}$$

$$= \mathbf{193.16\ Hz}$$

(f) $$f_{1_{low}} \cong \mathbf{193.16\ Hz}$$

(g)(h)