Elektronik II

Feedback Amplifier Examples

Original notes: Ders13.pdf

UYARI Bu belge, el yazısı ders notlarından Claude (Anthropic) yardımıyla dijitale aktarılmıştır. Yardımcı kaynak olarak hazırlanmıştır; hata veya eksik içerebilir. Lütfen orijinal notları ve ders kaynaklarını esas alın.

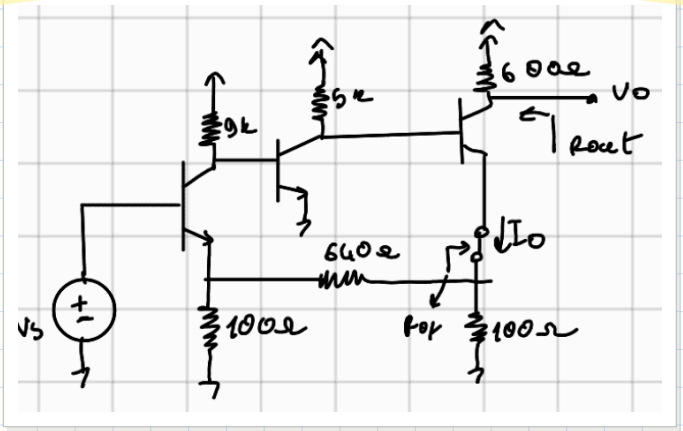
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orig. p. 1

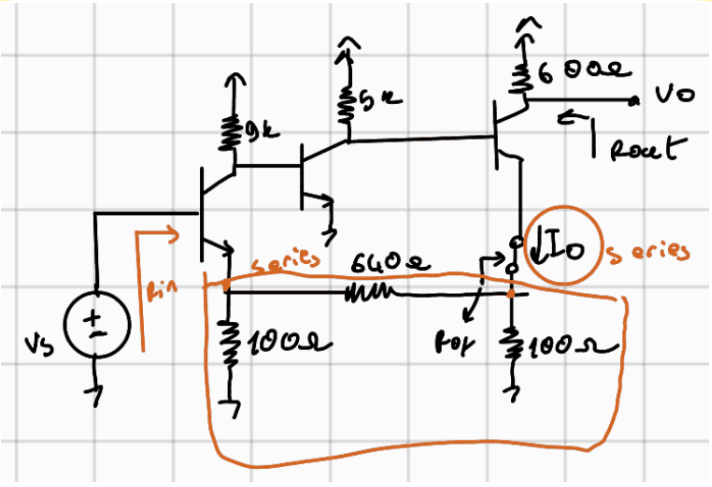
Example

Analyze the circuit given below (Transconductance Amplifier) (Series-Series)

$I_{C1} = 0{,}6\,\text{mA}$, $I_{C2} = 1\,\text{mA}$, $I_{C3} = 4\,\text{mA}$ $[\beta = 100, r_o = \infty]$ Find A, β, $A_f = \frac{I_o}{V_s}, \frac{V_o}{V_s}$



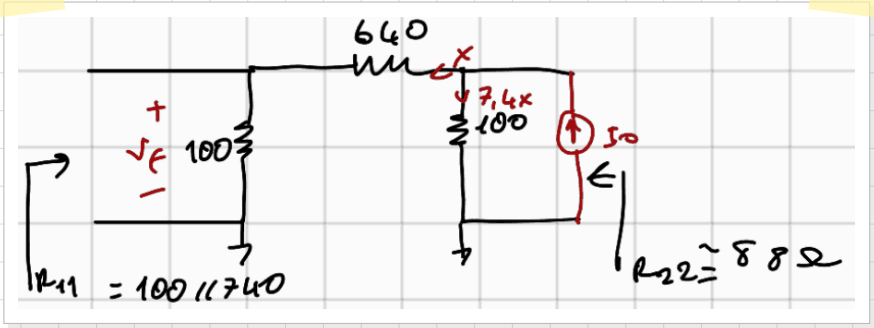
original drawing, p. 1



original drawing, p. 1

$$g_{m1} = \frac{0{,}6\,mA}{25\,mV} = 24\,mS$$
$$g_{m2} = \frac{1\,mA}{25\,mV} = 40\,mS$$
$$g_{m3} = \frac{4\,mA}{25\,mV} = 10\,mS^{1}$$

$$r_{\pi 1} = \frac{1000}{24} \times 100 = 4{,}2k$$
$$r_{\pi 2} = 2{,}5k$$
$$r_{\pi 3} = 0{,}625k$$

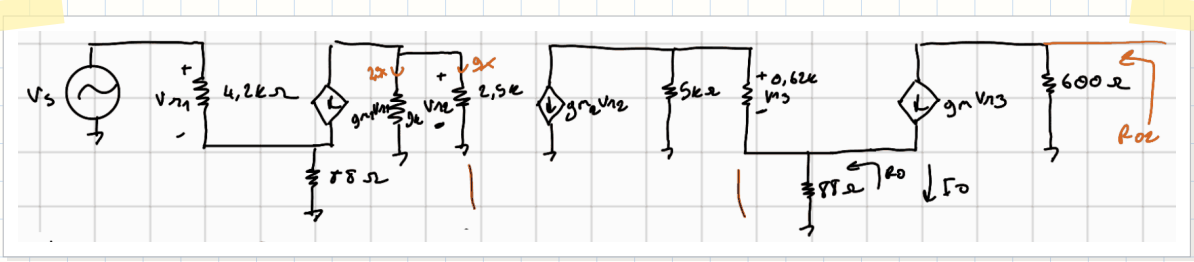


original drawing, p. 1

$$R_{11} = 100 \parallel 740 = 88\,\Omega$$
$$R_{22} \approx 88\,\Omega$$

$$\beta = \frac{V_f}{I_o} = \frac{100x}{8{,}4x} = 11{,}9\,\Omega$$

orig. p. 2



original drawing, p. 2

$$v_s = v_{\pi 1} + 88\left(0{,}024\,v_{\pi 1} + \frac{v_{\pi 1}}{4200}\right)$$
$$v_s \approx 3{,}03\,v_{\pi 1}$$

[1] Claude notu: muhtemelen 160 mS olmalı (4 mA/25 mV; $r_{\pi 3} = 0{,}625k$ ile tutarlı).

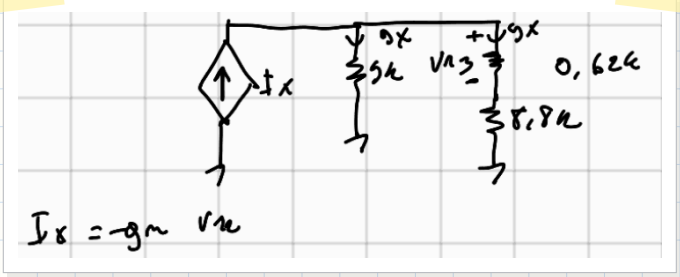
$$v_{\pi 2} = \frac{-24\,\text{mS}\; v_{\pi 1} \times 2{,}5\text{k} \times 9\text{k}}{11{,}5\text{k}}$$

$$v_{\pi 2} = -47\, v_{\pi 1}$$

$$I_o = g_{m3}\, v_{\pi 3} + \frac{v_{\pi 3}}{0{,}62\text{k}} \qquad (R_o \cdot (\beta + 1) + 0{,}62\text{k})$$

$$v_{\pi 3} = 3{,}1x = -8{,}86\, v_{\pi 2}$$

$$= -g_{m2}\, v_{\pi 2}\, \frac{3{,}1}{14}$$



original drawing, p. 2

$$I_x = -g_m\, v_{\pi 2}$$

$$\frac{I_x \cdot 5\text{k}}{(14\text{k})} \cdot 0{,}62\text{k}$$

$$V_s = \frac{-3{,}03}{47} \cdot \frac{-I_o}{8{,}57} \cdot \frac{1}{0{,}16} = \frac{I_o}{V_o}^{2} \approx 21{,}27\ [A/V]$$

$$R_i = 4{,}2\text{k} + 88 \times 100$$

$$R_i = 4{,}2\text{k} + 8{,}8\text{k} = 13\text{k}\Omega$$

$$R_o = 88 + \frac{5\text{k} + 0{,}62\text{k}}{100} = 144{,}2\,\Omega$$

$$R_{o2} = 600\,\Omega$$

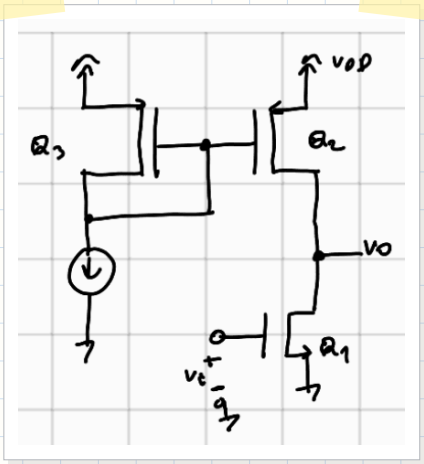
$$R_{if} = (1 + A\beta)\, R_i = 1086\,\Omega$$

$$R_{of} = (1 + A\beta)\, R_o = \text{?}\,12{,}09\,\Omega$$

$$A_f = \frac{21{,}27}{1 + 21{,}27 \times 11{,}9} = 0{,}0837$$

[2] Claude notu: muhtemelen I_o/V_s olmalı (sonuç $A = I_o/V_s$ için).

orig. p. 3



original drawing, p. 3

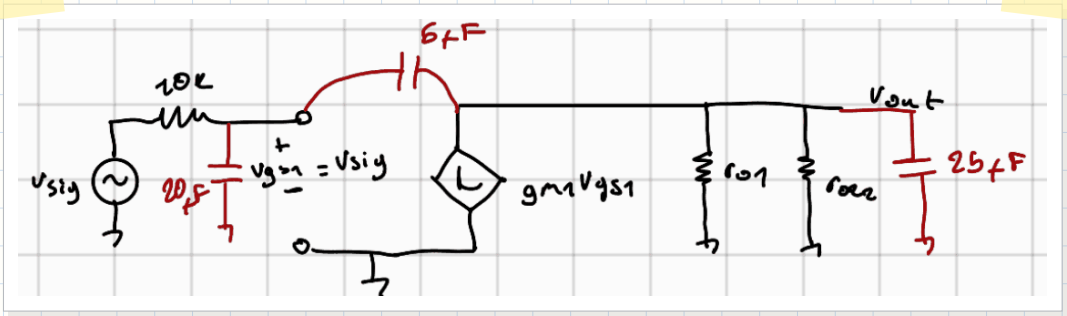
Consider the active loaded common source amplifier given at left
$(W/L) = \dfrac{7\,\mu m}{0{,}4\,\mu m}$ for all trans

$$\mu_n C_{ox} = 387\ \mu A/V^2$$
$$\mu_p C_{ox} = 86\ \mu A/V^2$$
$$I_{ref} = 100\ \mu A$$
$$V'_{An} = 5\ V/\mu m$$
$$V'_{Ap} = 10\ V/\mu m$$
$$V_A = V'_A L$$

For Q_1, $C_{gs} = 20\,fF$, $C_{gd} = 5\,fF$, $C_L = 25\,fF$ and $R_{sig} = 10k\Omega$. Assuming that C_L represents all the capacitance at that node.
Find f_H with open time constant and Miller approaches

$$I_D = 100\ \mu A = \frac{1}{2} \cdot 387\ \mu A/V^2 \cdot 20\,(V_{ov})^2$$
$$V_{ov} = \sqrt{\frac{10}{387}} = \pm 0{,}16 \longrightarrow +0{,}16\ V$$

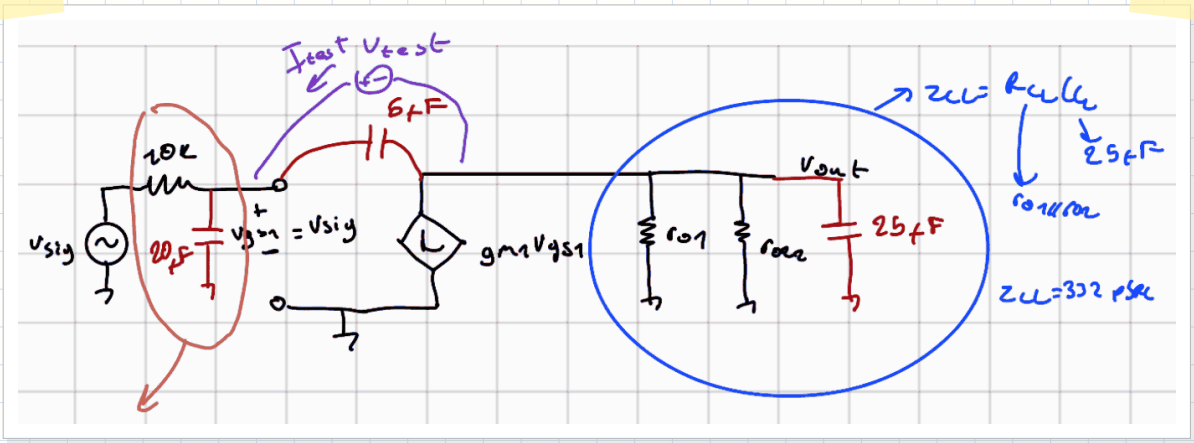
$$g_{m1} = \frac{2 \times 100\ \mu A}{0{,}16\ V} = 1{,}25\ mS$$
$$r_{o1} = \frac{5\ V/\mu m \times 0{,}4\ \mu m}{100\ \mu A} = 20\ k\Omega$$
$$r_{o2} = \frac{10\ V/\mu m \times 0{,}4}{100\ \mu A} = 40\ k\Omega$$



original drawing, p. 3

$$A_M = -g_{m1}(r_{o1} \parallel r_{o2})$$
$$= -1{,}25\,\text{mS}\,(20\text{k} \parallel 40\text{k})$$
$$A_M = -16{,}6\ [\text{V/V}]$$

orig. p. 4

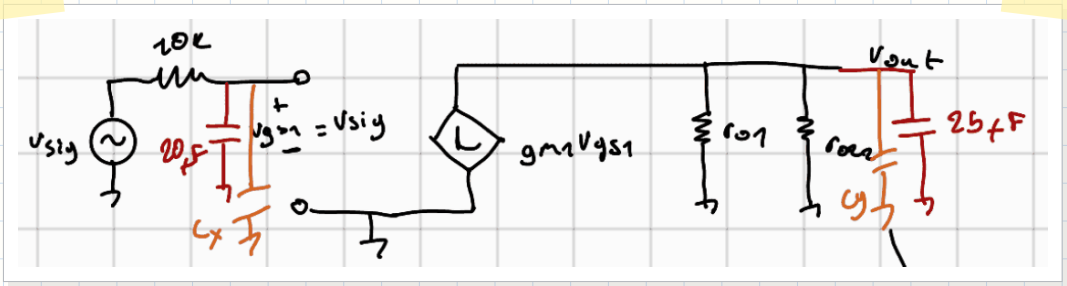


original drawing, p. 4

$$R_{C1} = R_{sig} = 10\,\text{k}\Omega$$
$$C_{C1} = C_{gs} = 20\,\text{fF}$$
$$\tau_{gs} = R_{C1}\,C_{C1} = 200\ \text{psec}$$

$$\tau_{CL} = \underbrace{R_{CL}}_{r_{o1} \parallel r_{o2}}\ \underbrace{C_L}_{25\,\text{fF}}$$
$$\tau_{CL} = 332\ \text{psec}$$

$$R_{gd} = R_{sig}(1 + g_m R'_L) + R'_L \qquad (R'_L = r_{o1} \parallel r_{o2})$$
$$\tau_{gd} = R_{gd} C_{gd} = 950 \text{ psec}$$
$$\tau = \tau_{gd} + \tau_{gs} + \tau_{CL}$$
$$= 1482 \text{ psec}$$
$$f = \frac{1}{2\pi\tau} = 107{,}4 \text{ MegHz}$$



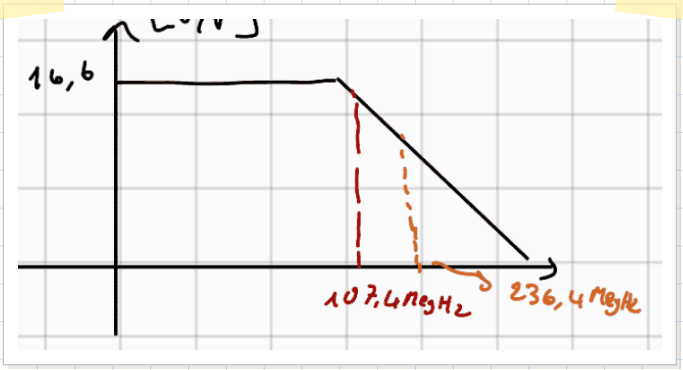
original drawing, p. 4

$$C_y = C_{gd}\left(1 + \frac{1}{g_m R'_L}\right) = 5 \text{ pF}^3$$

$$C_x = (1 - g_m R'_L) C_{gd}{}^4$$
$$C_x = 88 \text{ pF}$$
$$C_1 = 88 + 20 = 108 \text{ pF}$$
$$f_{p1} = \frac{1}{2\pi(108 \text{ pF})} = 294 \text{ MHz}$$
$$C_2 = 30 \text{ pF}$$
$$f_{p2} = \frac{1}{2\pi(30 \text{ pF})13{,}3k} = 399 \text{ MHz}$$
$$f_H = \sqrt{\frac{1}{\frac{1}{(f_{p1})^2} + \frac{1}{(f_{p2})^2}}}$$
$$f_H \approx 236{,}4 \text{ MegHz}$$

[3] Claude notu: birimler muhtemelen fF olmalı (şekildeki $C_{gd} = 5$ fF, $C_L = 25$ fF ile uyumlu); aşağıdaki pF ifadeleri için de geçerli.

[4] Claude notu: muhtemelen $(1 + g_m R'_L)$ olmalı (88 sonucu ile uyumlu).



original drawing, p. 4