Svar Elektronik 8 juni 2016

1a. $P_{f\,max} = \frac{150^\circ - 40^\circ}{2^\circ C/W + 20^\circ C/W} = \underline{5W}$

1b. Metallfilmmotstånd har <u>induktans</u>

Kolmassamotstånd har <u>brus</u>

1c. $\omega_0' = (1+\beta A)\cdot 25\,rad/s = \left(1 + \frac{1k}{1k+99k}\cdot 10^5\right)\cdot 25\,rad/s \approx$

$\approx \underline{25{,}03\,krad/s}$

1d. $i_D = \frac{16V-12V}{1k\Omega} = 4mA \;\therefore\; 4mA = \frac{4mA/V^2}{2}(V_{GS}-3V)^2 \Rightarrow$

$V_{GS} = 4{,}41V \;.\; V_S = 10V - V_{GS} = 5{,}59V \Rightarrow$

$R_S = \frac{5{,}59V}{4mA} \approx \underline{1{,}40k\Omega}$

1e. primärbatterier är ej <u>laddningsbara</u>

Sekundärbatterier är <u>laddningsbara</u>

1f. Reella poler: $s^2 + 8bs + 5 = 0 \Rightarrow$

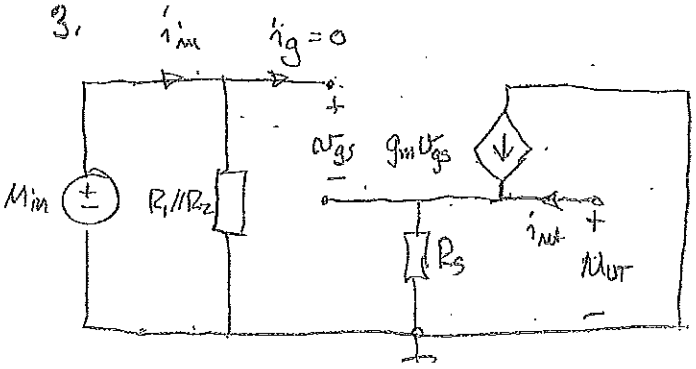
$s = -4b \pm \sqrt{16b^2 - 5} \Rightarrow \underline{|b| > \frac{\sqrt{5}}{4} = 0{,}559}$

2. $v_+ = 187{,}2\,mV$.

$$\frac{v_- + 0{,}1V}{6{,}8k} + \frac{v_- - v_o}{100k} = 0 \qquad v_- = v_+ = 187{,}2mV \Rightarrow$$

$$\underline{v_o \approx 4{,}41V}$$

3.



$$v_{in} = v_{gs} + g_m v_{gs} \cdot R_S \;, \quad v_{out} = g_m v_{gs} R_S \Rightarrow$$

$$\frac{v_{out}}{v_{in}} = \frac{g_m R_S}{1 + g_m R_S} \;, \quad g_m = \sqrt{2k \cdot I_D} = 4mA/V \Rightarrow$$

$$\underline{\frac{v_{out}}{v_{in}} = \frac{8}{9} \approx 0{,}89}$$

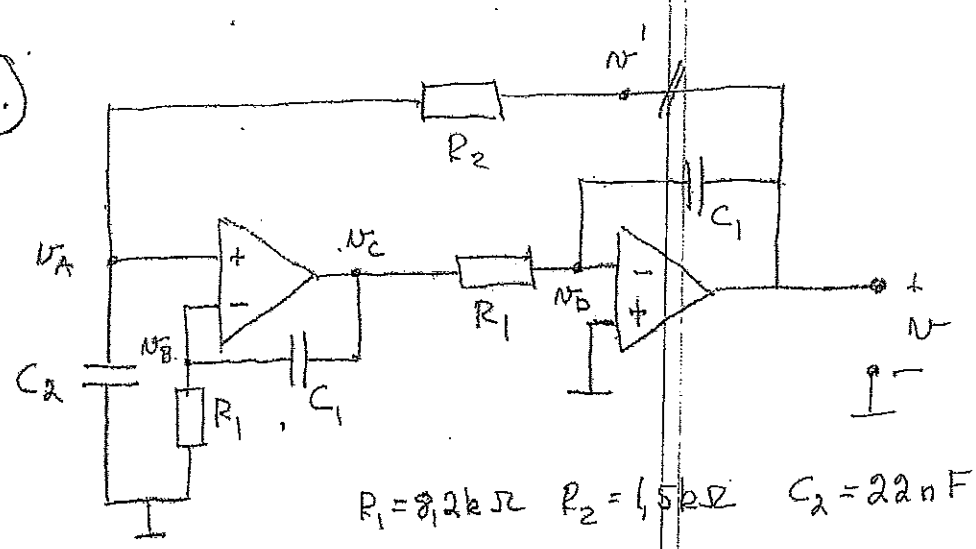
$$R_{in} = \frac{v_{in}}{i_{in}} = R_1 // R_2 = \underline{68{,}75k\Omega}$$

$$R_{out} = \left.\frac{v_{out}}{i_{out}}\right|_{v_{in}=0} \;, v_{in} = 0 \Rightarrow v_{out} = -v_{gs}.$$

$$v_{out} = R_S\left(i_{out} + g_m v_{gs}\right) = R_S\left(i_{out} - g_m v_{out}\right) \Rightarrow$$

$$R_{out} = \frac{R_S}{1 + g_m R_S} \approx \underline{222\Omega}$$

(4.)



$R_1 = 8{,}2\,k\Omega \quad R_2 = 1{,}5\,k\Omega \quad C_2 = 22\,nF$

Ideala motkopplade OP $\Rightarrow$ • Ingångsmar = 0

• $v_A = v_B$; $v_D = 0$

Teckna $T(s) = \frac{v}{v'}$ och lös

ekvationen $T(j\omega) = 1$.

Nodanalys: • $\frac{v_A - v'}{R_2} + \frac{v_A}{1/sC_2} = 0 \Rightarrow$

$$v_A = \frac{v'}{1+sR_2C_2} \quad (1)$$

• $\frac{v_B}{R_1} + \frac{v_B - v_C}{1/sC_1} = 0 \Rightarrow v_B = \frac{sR_1C_1}{1+sR_1C_1} \cdot v_C \quad (2)$

(1) och (2) ger $v' = \frac{sR_1C_1(1+sR_2C_2)}{1+sR_1C_1} \cdot v_C \quad (3)$

• $\frac{v_D - v_C}{R_1} + \frac{v_D - v}{1/sC_1} = 0$; $v_D = 0 \Rightarrow$

$$v_C = -sR_1C_1 \cdot v \quad (4)$$

(3), (4) ger nu att

$$V' = -s^2 R_1^2 C_1^2 \cdot \frac{1+sR_2C_2}{1+sR_1C_1} V \Rightarrow$$

$$T(s) = \frac{V}{V'} = -\frac{1}{s^2 R_1^2 C_1^2} \cdot \frac{1+sR_1C_1}{1+sR_2C_2} \Rightarrow$$

$$T(j\omega) = -\frac{1}{-\omega^2 R_1^2 C_1^2} \cdot \frac{1+j\omega R_1C_1}{1+j\omega R_2C_2}, \quad T(j\omega) = 1 \Rightarrow$$

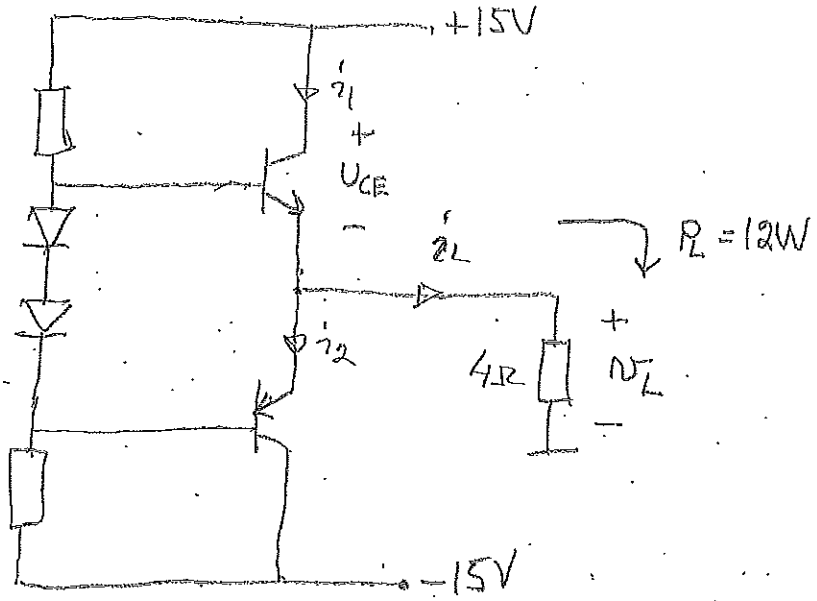
- $R_1C_1 = R_2C_2$
- $\omega^2 R_1^2 C_1^2 = 1 \Rightarrow$

$$C_1 = \frac{R_2C_2}{R_1} = \frac{1,5k\Omega}{8,2k\Omega} \cdot 22nF = \underline{\underline{4,02nF}}$$

$$\omega = \frac{1}{R_1C_1} = \frac{1}{8,2\cdot10^3 \cdot 4,02\cdot10^{-9}} = \underline{\underline{30,3krad/s}} \Rightarrow$$

$$f = \underline{\underline{4,82kHz}}$$

5



$$\cdot\ P_L = 4\Omega \cdot \frac{\hat{i}_L^2}{2} \Rightarrow \hat{i}_L = \sqrt{\frac{2 \cdot 12W}{4\Omega}} = \underline{2,45A}$$

$$\Rightarrow \hat{i}_1 = \underline{2,45A}$$

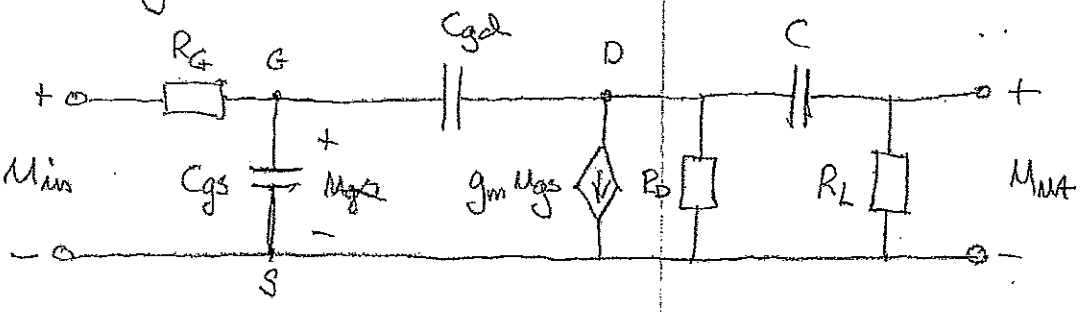
$$\cdot\ P_{in} = 2 \cdot 15V \cdot \frac{\hat{i}_1}{\pi} = 30V \cdot \frac{2,45A}{\pi} = \underline{23,39W} \Rightarrow$$

$$\eta = \frac{P_L}{P_{in}} = \frac{12W}{23,39W} = \underline{51,3\%}$$

$$\cdot\ P_{E\text{-}Transistor} = \frac{P_{in} - P_L}{2} = \underline{5,70W}$$

$$\cdot\ P_{L\,max} = \frac{(\hat{U}_{L\,max})^2}{2 \cdot 4\Omega} = \frac{(15V)^2}{2 \cdot 4\Omega} = \underline{28,1W}$$

(6). Småsignalschema



$R_G = 800\Omega$, $R_D = 4k\Omega$, $R_L = 4k\Omega$, $C = 200nF$

$g_m = 40mA/V$, $C_{gs} = 30pF$, $C_{gd} = 4pF$.

Vi delar upp beräkningen i:

a. höga frekvenser (betyder $\frac{1}{\omega C} \approx 0$, $\frac{1}{\omega C_{gs}} > 0$, $\frac{1}{\omega C_{gd}} > 0$)

b. låga frekvenser (betyder $\frac{1}{\omega C} > 0$, $\frac{1}{\omega C_{gs}} = \frac{1}{\omega C_{gd}} = \infty$)

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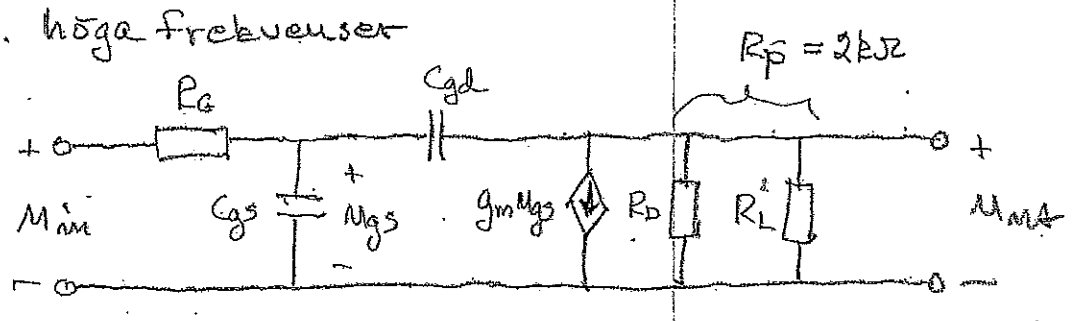
a. höga frekvenser



C_{gd} delas approximativt upp med Millers sats

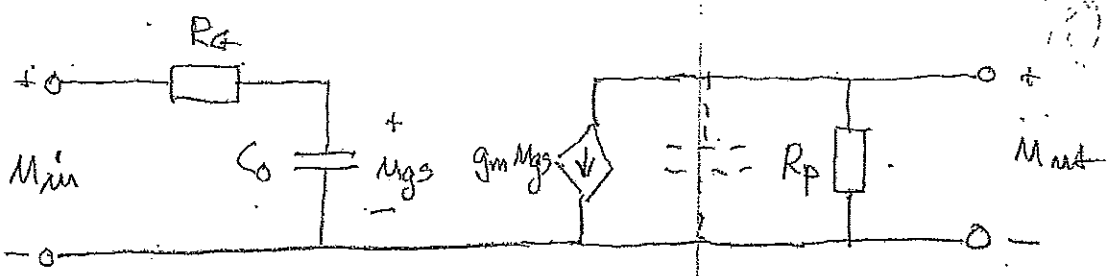
$C_{M1} = (1-k) C_{gd}$; $C_{M2} = (1 - \frac{1}{k}) C_{gd}$ där

$k \approx \frac{U_{ut}}{U_{gs}}$ (utan C_{gd}) $= \frac{-g_m U_{gs} \cdot R_P}{U_{gs}} = -g_m \cdot R_D // R_L =$

$\simeq -40mA/V \cdot (4k\Omega // 4k\Omega) = -80$ggr $\Rightarrow$

$C_{M1} = 81 \cdot 4pF = \underline{324pF}$, $C_{M2} = (1 + \frac{1}{81}) \cdot 4pF \approx \underline{4,05pF}$

Inverkan av C_{M2} försummas ofta eftersom den ger en pol flera 10-potenser högre än C_{M1}. $\Rightarrow$



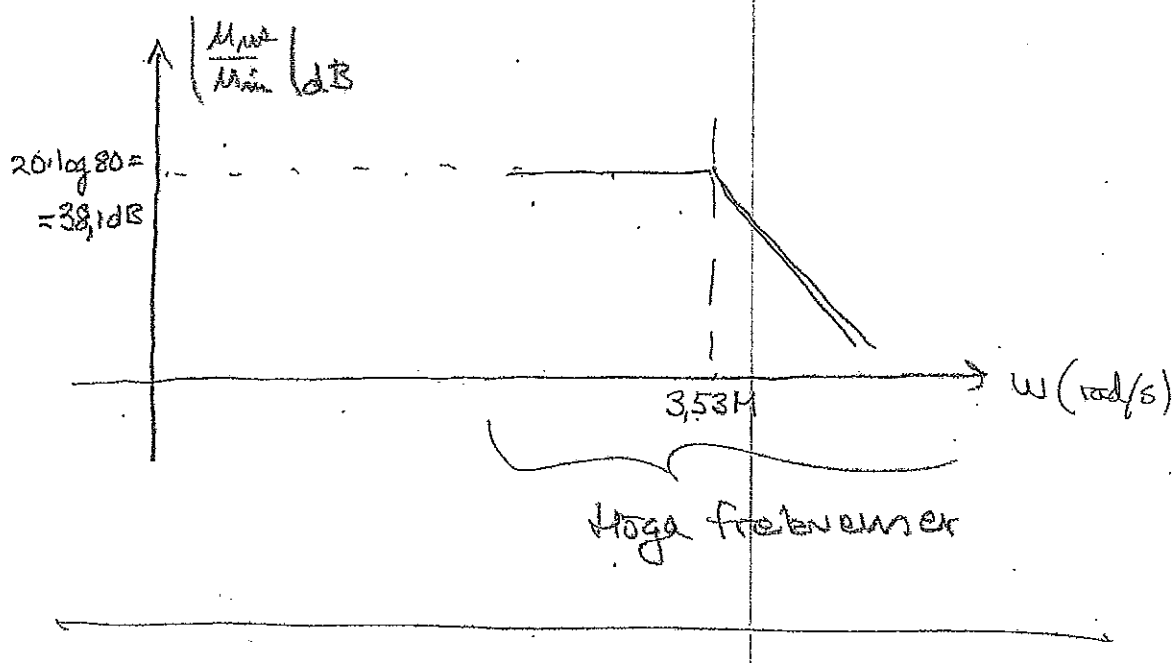
$$C_0 = C_{M1} + C_{gs} = 324\,pF + 30\,pF = \underline{354\,pF}.$$

$$u_{ut} = -g_m u_{gs} R_p$$

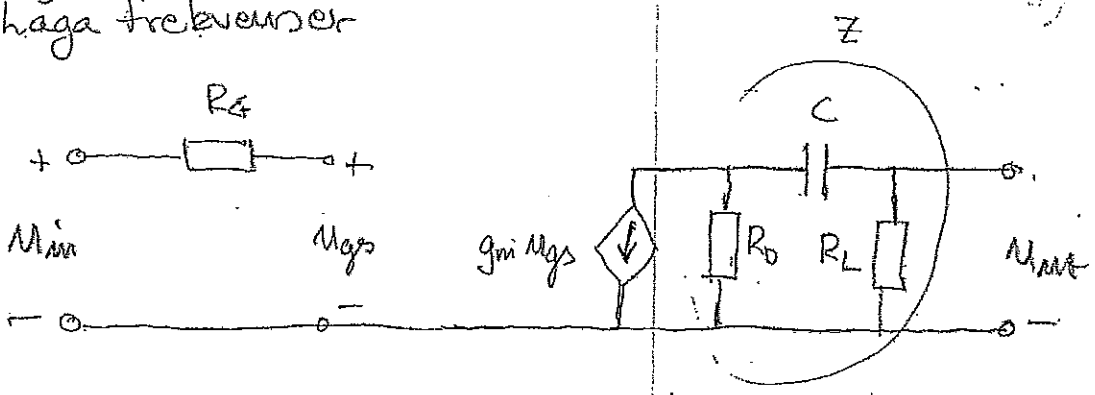
$$u_{gs} = \frac{\frac{1}{sC_0}}{R_G + \frac{1}{sC_0}} \cdot u_{in} = \frac{1}{1+sR_G C_0} \cdot u_{in} \Rightarrow$$

$$\frac{u_{ut}}{u_{in}} = -\frac{g_m R_p}{1+sR_G C_0} = -\frac{40\,mA/V \cdot 2\,k\Omega}{1+s \cdot 800\,\Omega \cdot 354 \cdot 10^{-9}\,F} =$$

$$\doteq -\frac{80}{1+\frac{s}{3{,}53 \cdot 10^6}} \Rightarrow$$ Den övre gränsvinkelfrekvensen är $\omega_0'' = 3{,}53\ Mrad/s$



b. Låga frekvenser



Spänningsdelning ger

$$u_{ut} = \frac{R_L}{R_L + \frac{1}{sC}} \cdot (-g_m u_{gs} \cdot Z) = -\frac{g_m s R_L C \cdot Z}{1 + s R_L C} \cdot u_{gs}$$

$$Z = R_D // \left(R_L + \frac{1}{sC}\right) = \frac{R_D \cdot \left(R_L + \frac{1}{sC}\right)}{R_D + R_L + \frac{1}{sC}} =$$

$$= \frac{R_D (1 + s R_L C)}{1 + s (R_D + R_L) \cdot C} \quad \therefore \; u_{gs} \approx u_{in} \Rightarrow$$

$$u_{ut} = -\frac{g_m s R_L C \cdot R_D (1 + s R_L C)}{(1 + s R_L C)(1 + s (R_D + R_L) C)} \cdot u_{in} = -\frac{g_m R_D R_L \cdot sC}{1 + s (R_D + R_L) C} \cdot u_{in}$$

$$= -\frac{40\text{mA/V} \cdot 4\text{k}\Omega \cdot 4\text{k}\Omega \cdot 200\text{nF} \cdot s}{1 + s (4\text{k}\Omega + 4\text{k}\Omega) \cdot 200\text{nF}} = -\frac{\frac{s}{7{,}81}}{1 + \frac{s}{625}} =$$

$$= -80 \cdot \frac{\frac{s}{625}}{1 + \frac{s}{6.25}} .$$

Detta ger max-förstärkning 80 ggr = 38,1 dB.

Undre gränsfrekvens av blir $\omega_u = 625 \text{ rad/s}$.

⇒

$\Rightarrow$ Hela Bode-diagrammet