(1) 09-01-13

a) Varaktor
Varicap – kapacitansdiod

b) Elektrolytkondensator

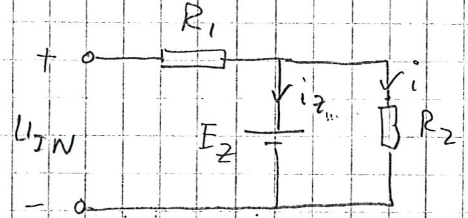
c) Drossel

d) $T_j - T_a = P_T \cdot \theta_{ja}$ där $\theta_{ja} = \theta_{jc} + \theta_{cs} + \theta_{sa}$

$\theta_{jc} = 1\,°C/W$, $\theta_{cs} = 0$, $\theta_{sa} = 2°C/W$, $T_{j_{max}} = 175°$
$T_a = 40°$

$$\underline{\underline{P_{T_{max}}}} = \frac{175-40}{1+2} = \underline{\underline{4.5\ Watt}}$$

e)



$U_{IN_{max}} \Rightarrow i_{z_{max}} \Rightarrow P_{z_{max}}$

$U_{IN_{max}} = (i + i_{z_{max}}) \cdot R_1 + E_Z$

$i = E_Z / R_2$

$$i_{z_{max}} = \left[U_{IN_{max}} - E_Z - \frac{E_Z \cdot R_1}{R_2}\right] / R_1 =$$

$$= \left[12 - 6 - 6 \cdot \frac{20}{60}\right] / 20 = 200\,mA$$

$$\therefore \underline{\underline{P_{z_{max}}}} = E_Z \cdot i_{z_{max}} = 6 \cdot 0{,}2 = \underline{\underline{1{,}2\ W}}$$

f) $P_{Batt} = 2 \cdot P_T + P_{R_L}$; $i(t) = 1{,}2 \cdot \sin \omega t$, $E = 15\,V$
$R_L = 10\,\Omega$

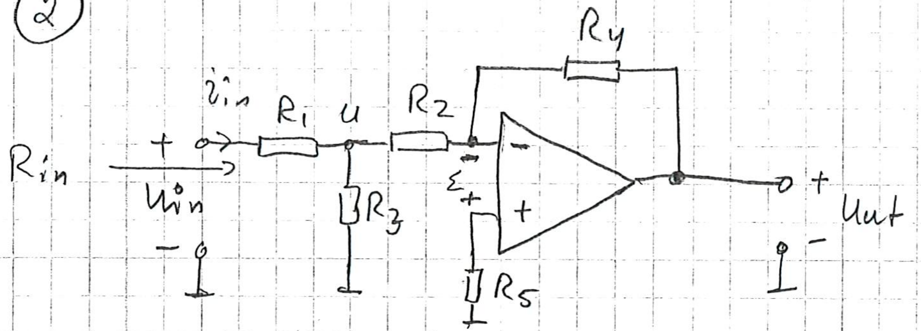
$$P_{Batt} = 2 \cdot E \cdot \frac{\hat{i}}{\pi} \simeq 11{,}46\ W$$

$$P_{R_L} = \frac{\hat{i}^2 \cdot R_L}{2} = 7{,}2\,W$$

Varje transistors effekt $\underline{\underline{P_T}} = \frac{11.5 - 7.2}{2} \simeq \underline{\underline{2{,}13\ Watt}}$

2

09-01-13



Neg återkoppl. / Ideal op-amp $\Big\}$ $\varepsilon = 0$ $\quad i_{op} = 0 \Rightarrow u^- = u^+ = 0$

$$\frac{U_{in} - u}{R_1} + \frac{-u}{R_3} + \frac{-u}{R_2} = 0 \Rightarrow \frac{U_{in}}{\cancel{R_1}} = u\,\frac{R_2 \cdot R_3 + R_1 R_2 + R_1 \cdot R_3}{\cancel{R_1} \cdot R_2 R_3}$$

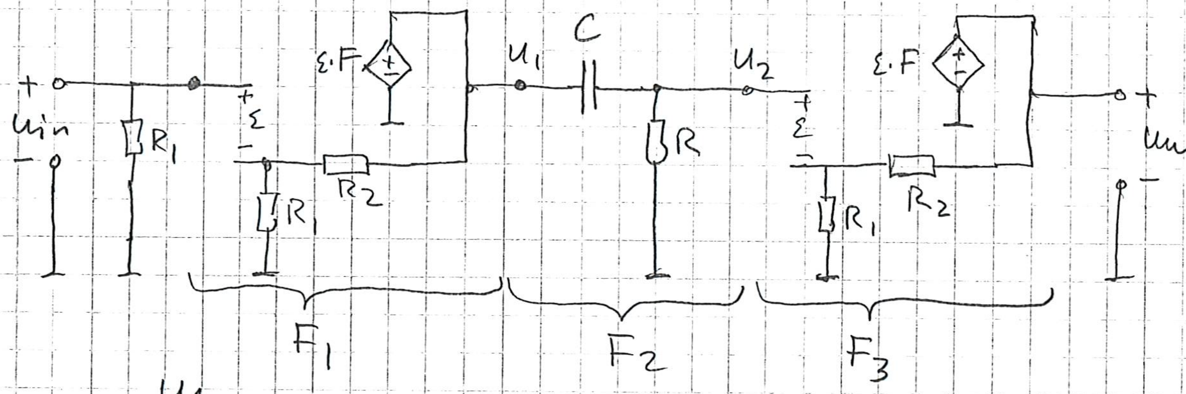
$$\frac{u}{R_2} + \frac{U_{ut}}{R_4} = 0 \Rightarrow \frac{U_{ut}}{u} = -\frac{R_4}{R_2}$$

$$\therefore \quad \underline{\underline{\frac{U_{ut}}{U_{in}}}} = -\frac{R_4}{\cancel{R_2}} \cdot \frac{\cancel{R_2} \cdot R_3}{R_2 \cdot R_3 + R_1 \cdot R_2 + R_1 \cdot R_3} = \underline{\underline{\frac{-R_3 \cdot R_4}{R_2 \cdot R_3 + R_1 \cdot R_2 + R_1 \cdot R_3}}}$$

$$\underline{\underline{R_{in}}} = \frac{U_{in}}{i_{in}} = \underline{\underline{R_1 + \frac{R_2 \cdot R_3}{R_2 + R_3}}}$$

(3) OP amp $\begin{cases} F = \dfrac{200.000}{1+s/30} = \dfrac{F_0}{1+s/\omega_1} \\ R_{in} = \infty \; ; \; R_{ut} = 0 \end{cases}$

04-01-13

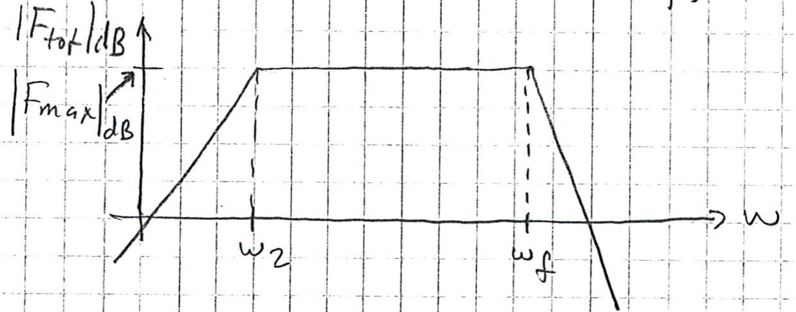


$$F_1 = F_3 = \frac{u_1}{u_{in}} \; ; \quad u_{in} = \varepsilon + \varepsilon \cdot F \cdot \frac{R_1}{R_1+R_2} \; ; \; u_1 = \varepsilon \cdot F$$

$$F_1 = F_3 = \frac{F}{1 + \underbrace{\frac{R_1}{R_1+R_2}}_{\beta} \cdot F} = \frac{F_0}{1 + s/\omega_1 + \beta \cdot F_0} = \underbrace{\frac{F_0}{1+\beta \cdot F_0}}_{F_{0f}} \cdot \frac{1}{1 + s/\underbrace{\omega_1(1+\beta F_0)}_{\omega_f}}$$

$$F_2 = \frac{u_2}{u_1} = \frac{R}{R + \frac{1}{sC}} = \frac{sRC}{1+sRC} = \frac{s/\omega_2}{1+s/\omega_2}$$

$$F_{tot} = F_1 \cdot F_2 \cdot F_3 = \left(\frac{F_{0f}}{1+s/\omega_f}\right)^2 \cdot \frac{s/\omega_2}{1+s/\omega_2}$$



$R_1 = 12k\Omega$, $R_2 = 100k\Omega$

$R = 10k\Omega$, $C = 270nF$

$$\underline{\underline{\omega_{0\,tot}}} = \omega_f \sqrt{2^{1/2}-1} = 30\left(1 + \frac{12k}{112k} \cdot 2 \cdot 10^5\right) \cdot \sqrt{2^{1/2}-1} = 414k \text{ rad/s}$$

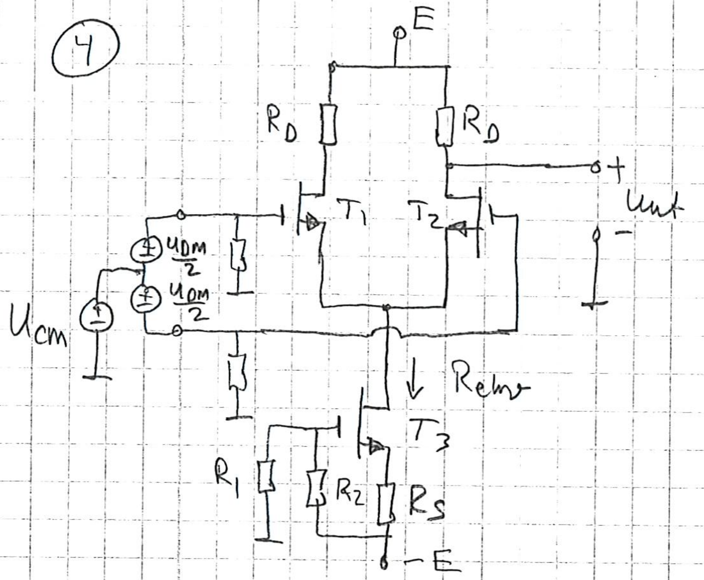
$$\underline{\underline{\omega_u}} = \omega_2 = \frac{1}{RC} = \underline{\underline{370 \text{ rad/sek}}}$$

$$F_{max} = F_{0f}^2 \cdot 1 \quad \text{ty } \omega_2 \ll \omega \ll \omega_f$$

$$\underline{\underline{F_{max}}} = \left(\frac{2 \cdot 10^5}{1 + \frac{12k}{112k} \cdot 2 \cdot 10^5}\right)^2 \approx \underline{\underline{87 \text{ ggr}}}$$

(4)

09-01-13



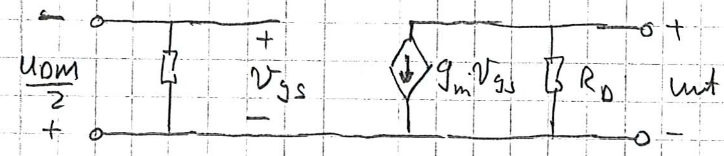
$$CMRR = \left| \frac{F_{DM}}{F_{CM}} \right|$$

$R_D = 6.8\,k\Omega$ $\quad R_S = 1\,k\Omega$

$g_m = 3\,mA/V$ $\quad (T_1$ o $T_2)$

$g_{m_3} = 5\,mA/V$, $r_{o_3} = 30\,k\Omega$ $\quad (T_3)$

F_{DM}: $U_{cm} = 0$, Source T_1, T_2 = virtuell jord.

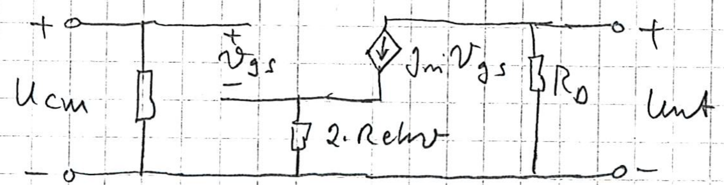


$$u_{ut} = -g_m \cdot v_{gs} \cdot R_D$$

$$-\frac{u_{DM}}{2} = v_{gs}$$

$$F_{DM} = \frac{u_{ut}}{u_{DM}} = \frac{g_m \cdot R_D}{2} = \frac{3m \cdot 6.8k}{2} = 10{,}2 \text{ ggr}$$

F_{CM}: $U_{DM} = 0$ $\quad$ Source T_1, T_2 ser Rekv in drain T_3

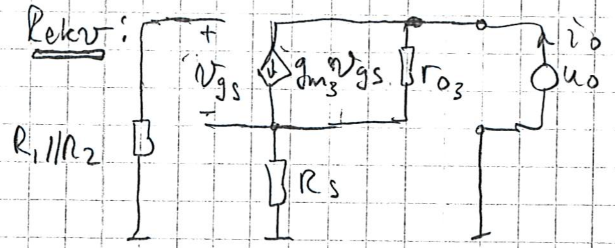


$$u_{ut} = -g_m \cdot v_{gs} \cdot R_D$$

$$u_{cm} = v_{gs} + g_m \cdot v_{gs} \cdot 2R_{ekv}$$

$$F_{CM} = \frac{u_{ut}}{u_{cm}} = \frac{-g_m \cdot R_D}{1 + g_m \cdot 2 \cdot R_{ekv}}$$

Rekv:



$$u_o = (i_o - g_{m_3} v_{gs}) r_{o_3} + i_o \cdot R_S$$

$$-v_{gs} = i_o \cdot R_S$$

$$R_{ekv} = \frac{u_o}{i_o} = (1 + g_{m_3} R_S) r_{o_3} + R_S = 181\,k\Omega$$

$$F_{CM} \approx -18{,}8 \cdot 10^{-3} \text{ ggr}$$

$$CMRR = \frac{10{,}2}{18.8 \cdot 10^{-3}} \approx 543 \text{ ggr} \Rightarrow 54{,}7\,dB$$

⑤ Småsignalschema: Mellanfrekvens: 09-01-13

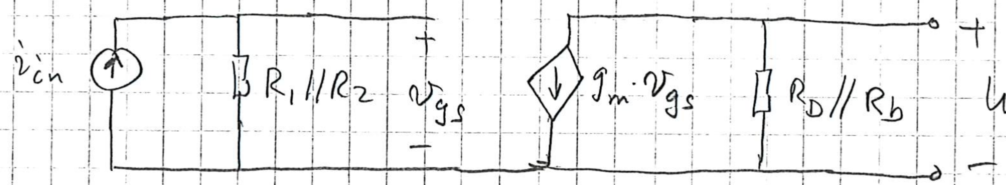
Antag C_{gs}, C_{gd}, C_b är avbrott (~pF)

C_s och C är kortslutna (~µF)

$R_S = 1{,}2k$, $R_D = 4{,}7k$, $R_1 = 33k$, $R_2 = 10k$, $R_b = 3{,}9k$

$k = 10m\,A/V^2$

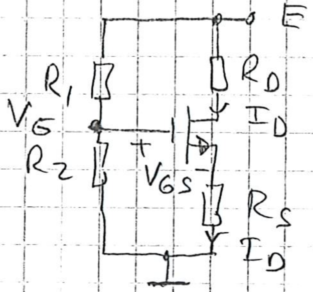
$V_t = 1{,}5V$



$$\left.\begin{aligned} v_{gs} &= i_{in} \cdot R_1//R_2 \\ u_{ut} &= -g_m \cdot v_{gs} \cdot R_D//R_b \end{aligned}\right\} \quad \frac{u_{ut}}{i_{in}} = -g_m \cdot R_1//R_2 \cdot R_D//R_b$$

g_m? $\quad g_m = \sqrt{2 \cdot k \cdot I_D}$ $\quad$ Bestäm I_D

Storsignalschema: Antag C_s, C avbrott; $i_{in} = 0$



$$I_D = \frac{k}{2}\left(V_{GS} - V_t\right)^2 = \frac{V_G - V_{GS}}{R_S}$$

$$V_{GS}^2 + \left(\frac{2}{k \cdot R_S} - 2 \cdot V_t\right)V_{GS} + V_t^2 - \frac{2 \cdot V_G}{k \cdot R_S} = 0$$

$E = 15V$ $\quad V_G = \frac{E \cdot R_2}{R_1 + R_2} = \frac{15 \cdot 10k}{33k + 10k} \approx 3{,}5\,\text{Volt}$

$$V_{GS}^2 + \left(\frac{2}{10m \cdot 1{,}2k} - 2 \cdot 1{,}5\right)V_{GS} + 1{,}5^2 - \frac{2 \cdot 3{,}5}{10m \cdot 1{,}2k} = 0$$

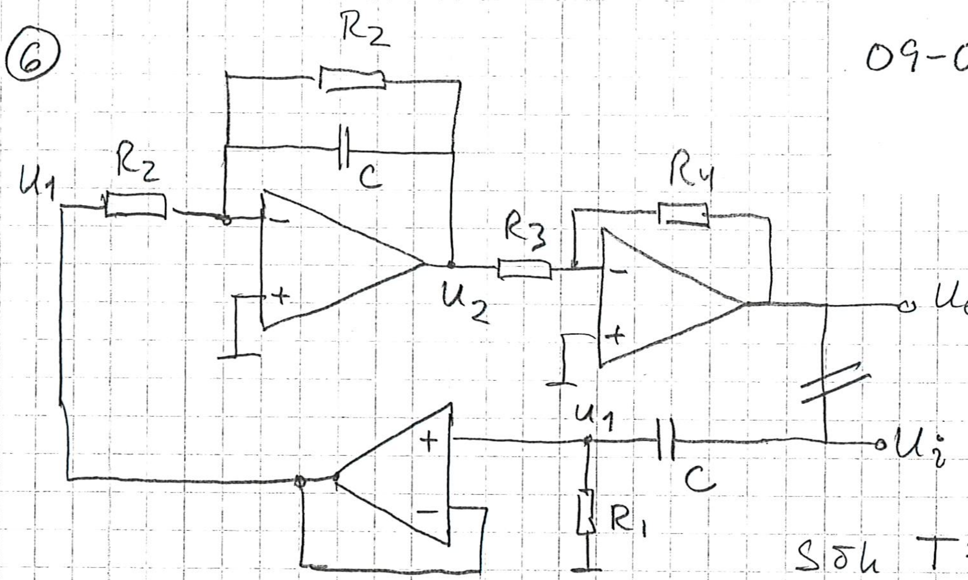
$$V_{GS}^2 - 2{,}83\,V_{GS} + 1{,}67 = 0 \qquad V_{GS} = 1{,}42 \pm \sqrt{1{,}42^2 - 1{,}67} = \begin{pmatrix} 2 \\ 0{,}831 \end{pmatrix}$$

$$\therefore \quad I_D = \frac{10m}{2}\left(2 - 1{,}5\right)^2 = 1{,}25\,mA$$

$$g_m = \sqrt{2 \cdot 10m \cdot 1{,}25m} = 5m\,A/V$$

$$\underline{\underline{\frac{u_{ut}}{i_{in}}}} = -5m \cdot \frac{33k \cdot 10k}{43k} \cdot \frac{4{,}7k \cdot 3{,}9k}{4{,}7k + 3{,}9k} \approx -82\,kV/A$$

⑥ 09-01-13



$C = 15\,nF$

$R_1 = 5\,k\Omega$

$R_2 = 20\,k\Omega$

$R_3 = 1\,k\Omega$

Sök $T = \frac{U_o}{U_i}$

Ideala op-amp. och Neg. återkoppling } $\Sigma = 0$

$$U_1 = \frac{U_i \cdot R_1}{R_1 + 1/sC} = U_i \cdot \frac{sR_1C}{1 + sR_1C}$$

$$\frac{U_2}{U_1} = -\frac{\cancel{R_2}}{1 + sR_2C} \cdot \frac{1}{\cancel{R_2}}$$

$$\frac{U_0}{U_2} = -\frac{R_4}{R_3}$$

$$T = \frac{U_0}{U_2} \cdot \frac{U_2}{U_1} \cdot \frac{U_1}{U_i} = \frac{R_4}{R_3} \cdot \frac{1}{1 + sR_2C} \cdot \frac{sR_1C}{1 + sR_1C}$$

$$T = \frac{R_4}{R_3} \cdot \frac{sR_1C}{s^2R_1R_2C^2 + s(R_1+R_2)C + 1}$$

$$T(j\omega) = \frac{R_4}{R_3} \frac{j\omega_0 R_1 C}{-\omega_0^2 R_1R_2C^2 + j\omega_0(R_1+R_2)C + 1} = 1$$ för sinus-oscillator

$\angle T$: Re[nämnare] = 0 $\quad -\omega_0^2 R_1R_2C^2 + 1 = 0 \Rightarrow$

$|T|$: Svängnings frekv: $\omega_0 = \frac{1}{C\sqrt{R_1R_2}} = \frac{1}{15n\sqrt{5k \cdot 20k}} = 6{,}67\ k$ rad/sek.

$$\underline{\underline{f_0 = \frac{\omega_0}{2\pi} = 1{,}060\ kHz}}$$

$$\frac{R_4}{R_3} \cdot \frac{\cancel{j\omega_0} \cdot R_1 \cancel{C}}{\cancel{j\omega_0}(R_1+R_2)\cancel{C}} = 1 \Rightarrow R_4 = \frac{(R_1+R_2) \cdot R_3}{R_1} = \frac{5k+20k}{5k} \cdot 1k$$

$$\underline{\underline{R_4 = 5\,k\Omega}}$$