Lösningar 20 aug 2008

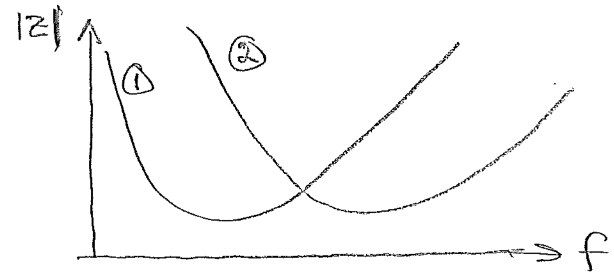
1 a. Primärbatterier är icke laddningsbara

ex. · brunsten
· alkaliska
· zink - luft

Sekundärbatterier är laddningsbara

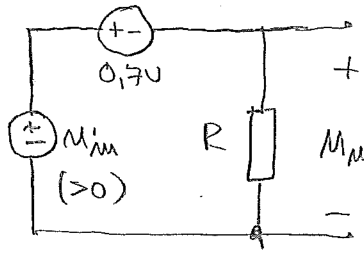
ex · blyackumulatorer
· Nickel - kadmium - batterier
· Nickel - metallhydrid - batterier
· Litium - jon - batterier

b, Kondensatorer av olika typ har olika frekvensberoende.
Liten impedans över stort frekvensområde kräver kombination av olika typer

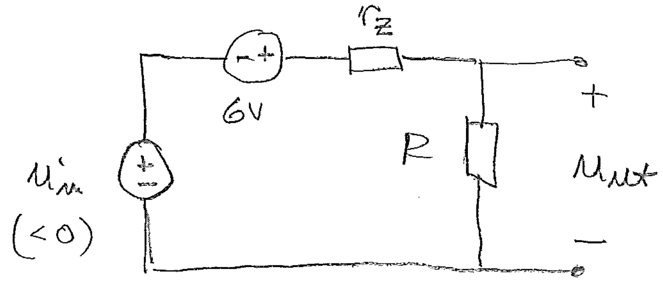


c. Ekvivalenta scheman

Framriktning



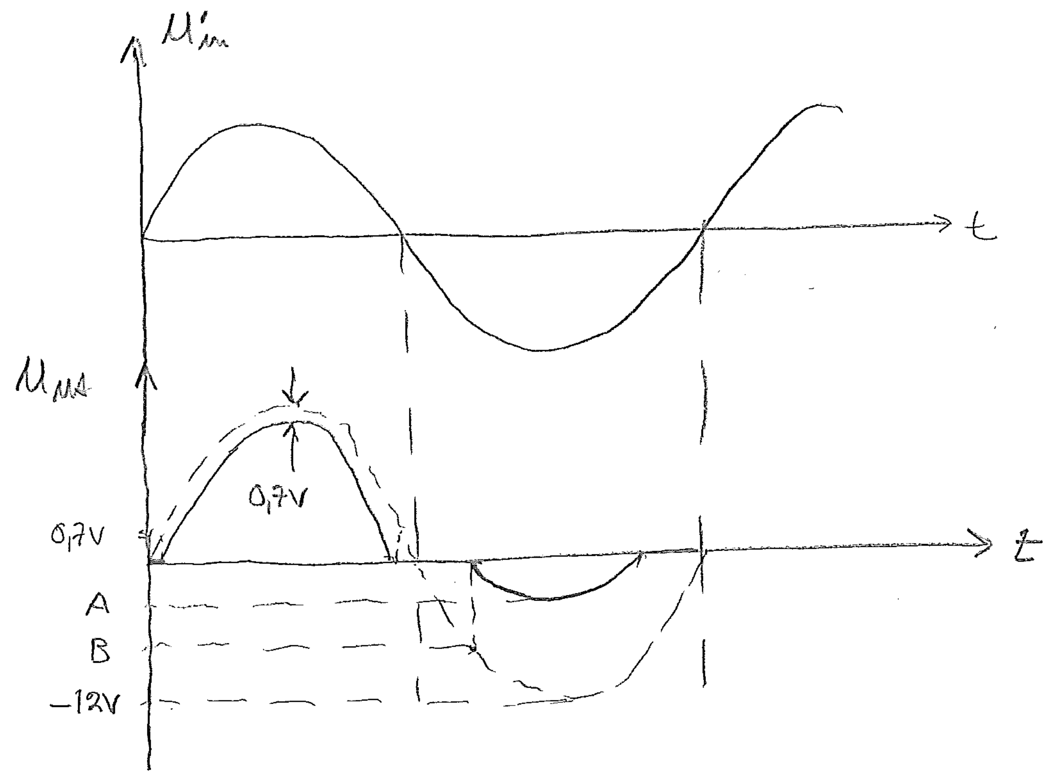
Backriktning



$R = 20\,\Omega$ $\quad r_Z = 2\,\Omega$ $\quad u_{in} = 12 \cdot \sin \omega t$ V

⟹

②

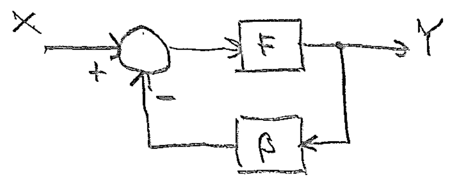


$\underline{A}$ $\quad u_{ut} = \frac{20\,\Omega}{2\,\Omega + 20\,\Omega} \cdot (-12V + 6V) = \underline{\underline{-5{,}45\,V}}$

$\underline{B}$ $\quad u_{in} = -6V$ (zenerdioden börjar leda i backriktningen)

1d. $\quad$ Klass A : $\eta_{max} = \underline{\underline{25\%}}$ $\quad$ Klass B : $\eta_{max} = \underline{\underline{78{,}5\%}}$

1e. $\quad F(s) = \dfrac{A_1 \cdot A_2}{\left(1+\frac{s}{\omega_1}\right)\left(1+\frac{s}{\omega_2}\right)}$



$$Y = F(s)\cdot(X - \beta \cdot F(s)) \Rightarrow H(s) = \frac{F(s)}{1+\beta\cdot F(s)} =$$

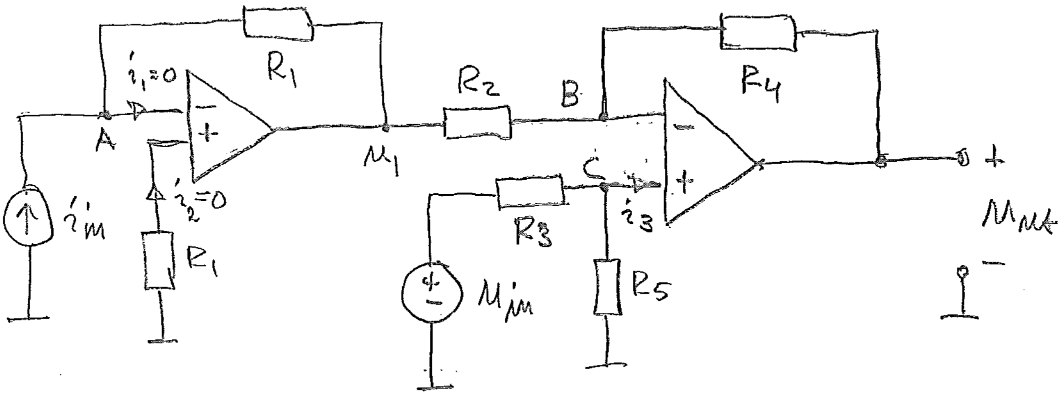
$$= \frac{\dfrac{A_1\cdot A_2}{\left(1+\frac{s}{\omega_1}\right)\left(1+\frac{s}{\omega_2}\right)}}{1+\beta\cdot\dfrac{A_1A_2}{\left(1+\frac{s}{\omega_1}\right)\left(1+\frac{s}{\omega_2}\right)}} = \frac{A_1A_2\omega_1\omega_2}{(s+\omega_1)(s+\omega_2)+\beta A_1A_2\omega_1\omega_2} =$$

$$= \frac{A_1A_2\omega_1\omega_2}{s^2+(\omega_1+\omega_2)s+\beta A_1A_2\omega_1\omega_2} \Rightarrow$$

$$s = \underbrace{-\frac{\omega_1+\omega_2}{2}}_{Re} \pm j\underbrace{\sqrt{\beta A_1A_2\omega_1\omega_2 - \frac{(\omega_1+\omega_2)^2}{4}}}_{Im}$$

1F. Z_{in} stor Z_{ut} liten $Z_{in} >> Z_{ut}$

2



$$u_{ut} = F(i_{in}, u_{in}) = ?$$

Motkopplade ideala OP $\Rightarrow$ • inströmmar = 0
• lika potentialer på ingångar.

Nodanalys:

A: $i_{in} + \frac{v_A - u_1}{R_1} = 0$; $v_A = R_1 \cdot i_2 = 0 \Rightarrow u_1 = R_1 \cdot i_{in}$ (1)

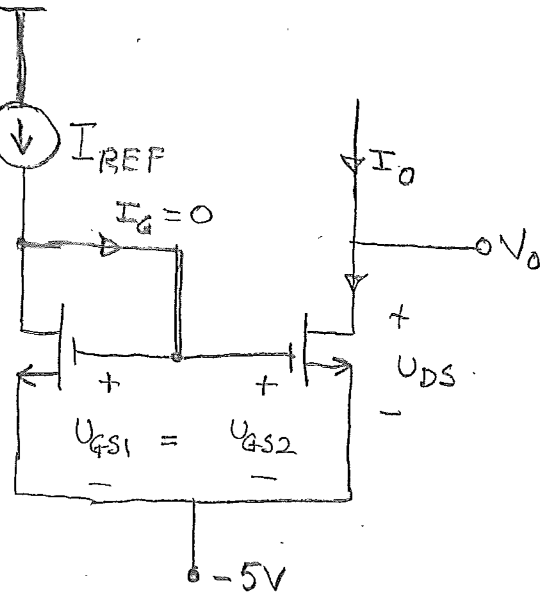
B: $\frac{v_B - u_1}{R_2} + \frac{v_B - u_{ut}}{R_4} = 0 \Rightarrow u_{ut} = \left(1 + \frac{R_4}{R_2}\right) \cdot v_B - \frac{R_4}{R_2} u_1$ (2)

$i_3 = 0 \Rightarrow v_C = \frac{R_5}{R_5 + R_3} \cdot u_{in}$; $v_B = v_C = \frac{R_5}{R_5 + R_3} \cdot u_{in}$ (3)

(1), (2), (3) $\Rightarrow$

$$u_{ut} = \left(1 + \frac{R_4}{R_2}\right) \cdot \frac{R_5}{R_5 + R_3} \cdot u_{in} - \frac{R_4}{R_2} \cdot R_1 \cdot i_{in}$$

3



$k = 0{,}08\,mA/V^2$

$V_t = 1V$

$V_A = 20V$

$I_{REF} = 10\mu A$

Lika resistorer och samma U_{GS} $\Rightarrow$

$I_0 = I_{REF} = 10\mu A$

Signalmässig utresistans $r_0 = \frac{V_A}{I_0} = \frac{20V}{10\mu A} = \underline{\underline{2M\Omega}}$

$U_{GS} = U_{GS1} = U_{GS2}$ ges av $I_{REF} = \frac{k}{2}(U_{GS} - V_t)^2$ vid

strömmättnad. $\Rightarrow$

$$10\mu A = \frac{0{,}08mA/V^2}{2}(U_{GS} - 1V)^2 \Rightarrow U_{GS} = 1V \pm 0{,}5V = \begin{cases} 1{,}5V \\ (0{,}5V) \end{cases}$$

Strömmättnad om $U_{DS} \geq U_{GS} - V_t$.

$U_{DS} = V_0 - (-5V) = V_0 + 5V \Rightarrow$

$$V_0 + 5V \geq 1{,}5V - 1V \Rightarrow \underline{\underline{V_0 \geq -4{,}5V}}$$

4) AC-analys. Bestäm först ett uttryck för $\frac{u_{ut}}{u_{in}}$ ur småsignalschemat.

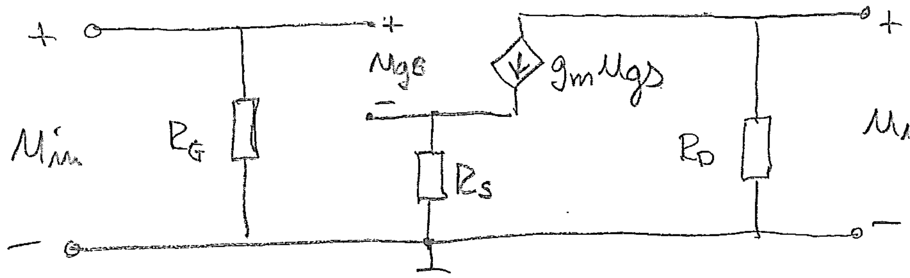
$k = 8\,mA/V^2$

$V_t = -1{,}5\,V$

(N-kanal utarmning)

$R_S = 200\,\Omega$

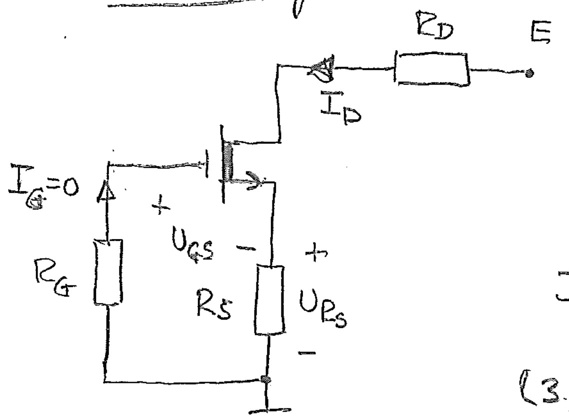
$\frac{1}{\omega C} \approx 0$



$$\left.\begin{aligned} &\cdot\ u_{in} = u_{gs} + g_m u_{gs} \cdot R_S = (1 + g_m R_S) \cdot u_{gs} \\ &\cdot\ u_{ut} = -g_m u_{gs} \cdot R_D \end{aligned}\right\} \Rightarrow$$

$$\frac{u_{ut}}{u_{in}} = -\frac{g_m R_D}{1 + g_m R_S} \quad (1)$$

DC-analys: Bestäm g_m ur $g_m = \sqrt{2k \cdot I_D}$ (2)



$I_G = 0 \Rightarrow$

$U_{RS} = -U_{GS} \Rightarrow I_D = \frac{-U_{GS}}{R_S}$ (3)

$I_D = \frac{k}{2}(U_{GS} - V_t)^2$ (4)

$(3), (4) \Rightarrow -\frac{U_{GS}}{R_S} = \frac{k}{2}(U_{GS} - V_t)^2$

$\Rightarrow (U_{GS} - V_t)^2 + \frac{2}{k \cdot R_S} \cdot U_{GS} = 0$

$\Rightarrow U_{GS}^2 + \left(\frac{2}{kR_S} - 2V_t\right) \cdot U_{GS} + V_t^2 = 0 \Rightarrow$ (utan enheter)

$U_{GS}^2 + 4{,}25\,U_{GS} + 2{,}25 = 0 \Rightarrow U_{GS} = \begin{cases} (-3{,}63\,V) \text{ (strypt)} \\ -0{,}625\,V \end{cases}$

$\Rightarrow I_D = -\frac{-0{,}625\,V}{200\,\Omega} = 3{,}125\,mA.\ (2) \Rightarrow g_m = 7\,mA/V.$

$(1) \Rightarrow \frac{7\,mA/V \cdot R_D}{1 + 7\,mA/V \cdot 200\,\Omega} = 3 \Rightarrow \underline{\underline{R_D = 1{,}03\,k\Omega}}$

5 Stegen belastar ej varandra $\Rightarrow$

$F_{TOT}(s) = F_1(s) \cdot F_2(s)$; så att

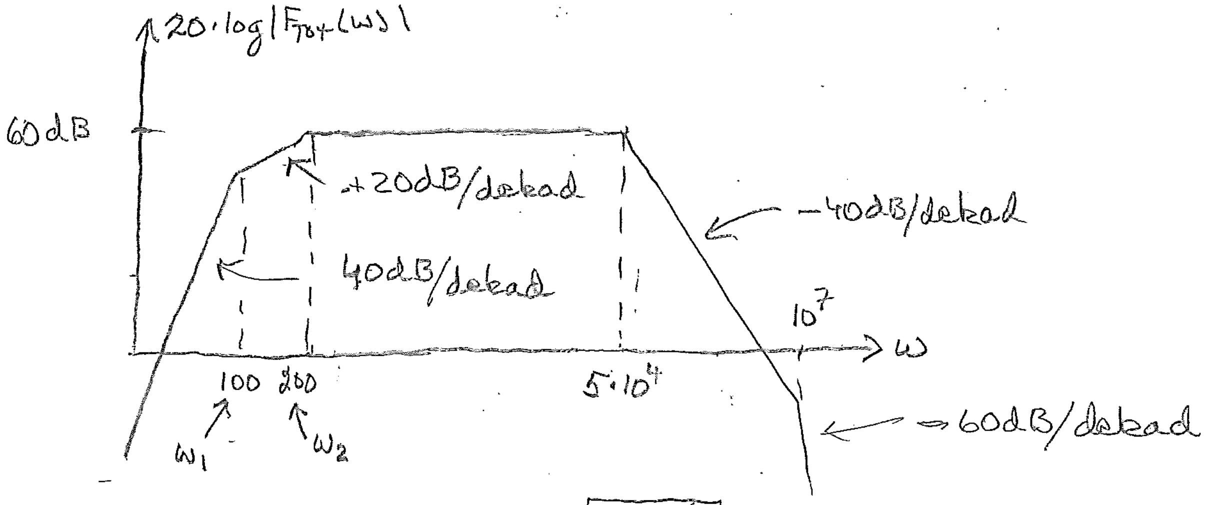
$$F_{TOT}(s) = \frac{-2 \cdot 10^{-3} \cdot s^2}{\left(1+\frac{s}{100}\right)\left(1+\frac{s}{200}\right)\left(1+\frac{s}{3000}\right)\left(1+\frac{s}{5\cdot 10^4}\right)} \cdot \frac{25 \cdot \left(1+\frac{s}{3000}\right)}{\left(1+\frac{s}{5\cdot 10^4}\right)\left(1+\frac{s}{10^7}\right)} =$$

$$= -\frac{5 \cdot 10^{-2} \cdot s^2}{\left(1+\frac{s}{100}\right)\left(1+\frac{s}{200}\right)\left(1+\frac{s}{5\cdot 10^4}\right)^2\left(1+\frac{s}{10^7}\right)}$$

$|F_{TOT}|_{max}$ ges av $200 \ll \omega \ll 5 \cdot 10^4$. Då gäller

$$|F_{TOT}(\omega)| \approx \frac{5 \cdot 10^{-2} s^2}{\frac{s}{100} \cdot \frac{s}{200} \cdot 1 \cdot 1} = 5 \cdot 10^{-2} \cdot 100 \cdot 200 = \underline{\underline{10^3 \text{ ggr}}} = \underline{\underline{60 \text{ dB}}}$$

Bode-diagram för $F_{TOT}(\omega)$:

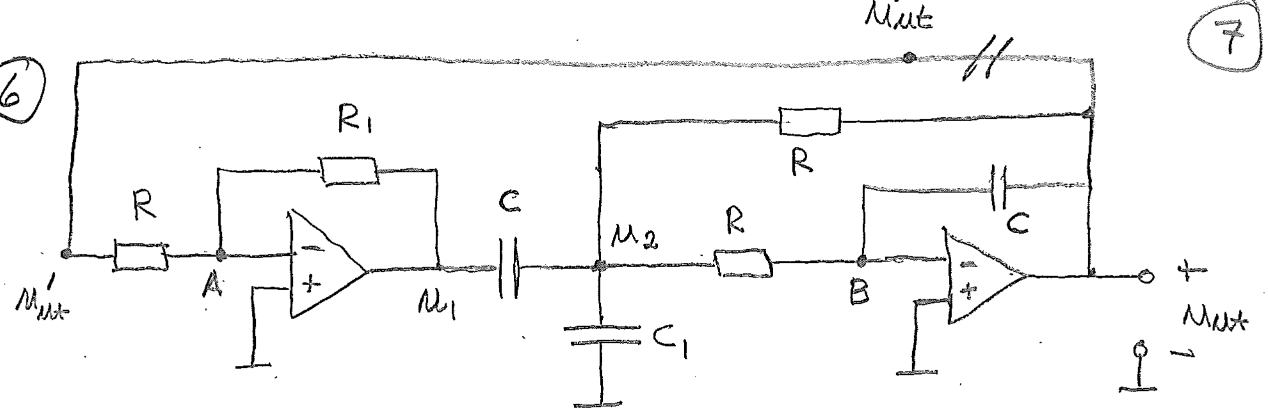


Dubbelpol $\Rightarrow$ $\omega_0'' = 5 \cdot 10^4 \cdot \sqrt{2^{1/2} - 1} = 32{,}18 \text{ krad/s} \Rightarrow$

$$\underline{\underline{F_0'' = 5{,}12 \text{ kHz}}}$$

$P_f = (\omega_1 + \omega_2) \cdot \Delta t \cdot 100\% = (100+200) \cdot 0{,}5 \cdot 10^{-3} \cdot 100\% = \underline{\underline{15\%}}$

6



Ideala motkopplade OP ⇒ inströmmar = 0, lika potential på ingångarna.

Bestäm $T(s)=\frac{u_{ut}}{u'_{ut}}$ och lös ekvationen $T(j\omega)=1$.

Nodanalys:

A: $\frac{v_A-u'_{ut}}{R}+\frac{v_A-u_1}{R_1}=0;\ v_A=0 \Rightarrow u_1=-\frac{R_1}{R}\cdot u'_{ut}$ (1)

B: $\frac{v_B-u_2}{R}+\frac{v_B-u_{ut}}{1/sC}=0;\ v_B=0 \Rightarrow u_2=-sRC\cdot u_{ut}$ (2)

u_2: $\frac{u_2-u_1}{1/sC}+\frac{u_2}{1/sC_1}+\frac{u_2-v_B}{R}+\frac{u_2-u_{ut}}{R}=0;\ v_B=0 \Rightarrow$

$u_2(sRC+sRC_1+2)-sRC\cdot u_1=u_{ut}$ (3)

(1) och (2) i (3) ger

$-sRC(sRC+sRC_1+2)\cdot u_{ut}+sRC\cdot\frac{R_1}{R}\cdot u'_{ut}=u_{ut} \Rightarrow$

$u_{ut}\left(1+s^2R^2C(C+C_1)+2sRC\right)=sR_1C\cdot u'_{ut} \Rightarrow$

$T(s)=\frac{sR_1C}{1+s^2R^2C(C+C_1)+2sRC} \Rightarrow T(j\omega)=\frac{j\omega R_1C}{1-\omega^2R^2C(C_1+C_2)+j\omega 2RC}$

$T(j\omega)=1 \Rightarrow 1-\omega^2R^2C(C+C_1)=0 \Rightarrow$

- $C_1=\frac{1}{\omega^2R^2C}-C=\underline{\underline{77\,nF}}$
- $\frac{j\omega R_1C}{j\omega 2RC}=1 \Rightarrow R_1=2R=\underline{\underline{40\,k\Omega}}$