Lösning på Elektronik 25 maj 2012

1a $T_j - T_a = P_F(R_{Thjc} + R_{Thcs} + R_{Thsa}) \Rightarrow$

$150°C - 40°C = 8W(2°C/W + 0°C/W + R_{Thsa}) \Rightarrow$

$110°C = 16°C + 8W \cdot R_{Thsa} \Rightarrow R_{Thsa} = \underline{\underline{11{,}8°C/W}}$

1b Resistorns parallella kapacitans gör att resistorns impedans minskar.

1c $I_{Zmax} = \frac{4W}{9{,}1V} = 439{,}5mA$

$u_{1max} = 20V \Rightarrow R_{min} = \frac{20V - 9{,}1V}{439{,}5mA} = \underline{\underline{25\,\Omega}}$

1d Klass AB-steget har högre maximal verkningsgrad (mindre förluster i tomgång).

1e Slew Rate = utspänningens maximalt möjliga stighastighet

1f $T(s) = \frac{a \cdot s}{s^2 + (b+100) \cdot s + 100b}$

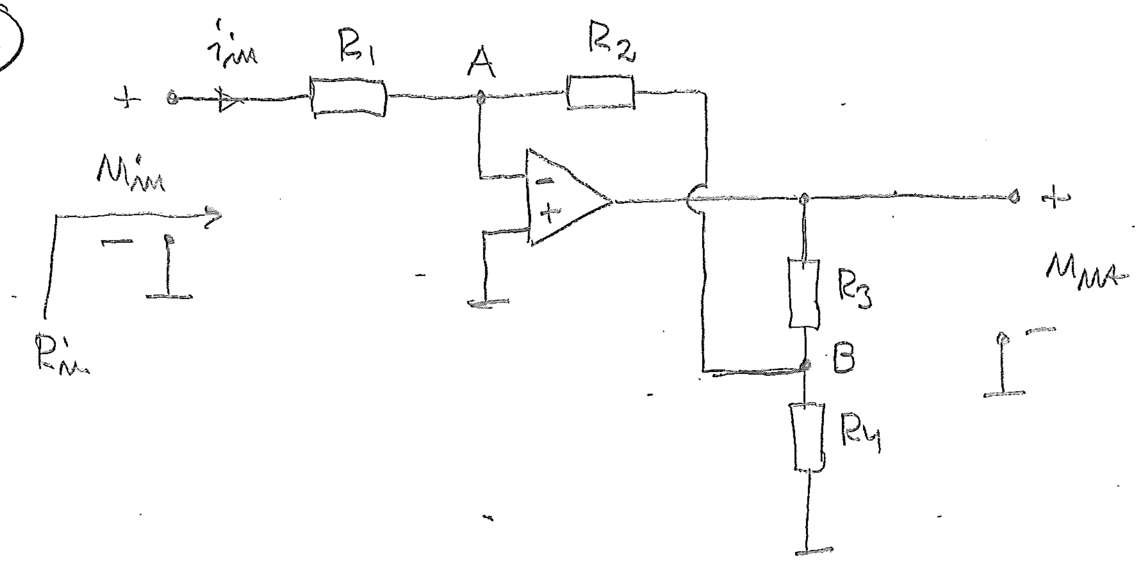
$T(j\omega) = 1 \Rightarrow \frac{ja\omega}{-\omega^2 + 100b + j(b+100)\omega} = 1$

$\omega = 100 \Rightarrow$

$100b = 100^2 \Rightarrow \underline{\underline{b = 100}}$

$\frac{a \cdot 100}{(b+100) \cdot 100} = 1 \Rightarrow a = b + 100 = \underline{\underline{200}}$

2



Ideal motkopplad OP $\Rightarrow$ · inströmmar $= 0$

· lika potential på ingångarna.

<u>R_{in}</u> : $\quad R_{in} = \dfrac{u_{in}}{i_{in}}$

$$v_A = 0 \Rightarrow i_{in} = \frac{u_{in}}{R_1} \Rightarrow R_{in} = \frac{u_{in}}{i_{in}} = \underline{\underline{R_1}}$$

<u>$\dfrac{u_{ut}}{u_{in}}$</u> : Nodanalys

<u>A</u>: $\dfrac{v_A - u_{in}}{R_1} + \dfrac{v_A - v_B}{R_2} = 0 \; ; \quad v_A = 0 \Rightarrow$

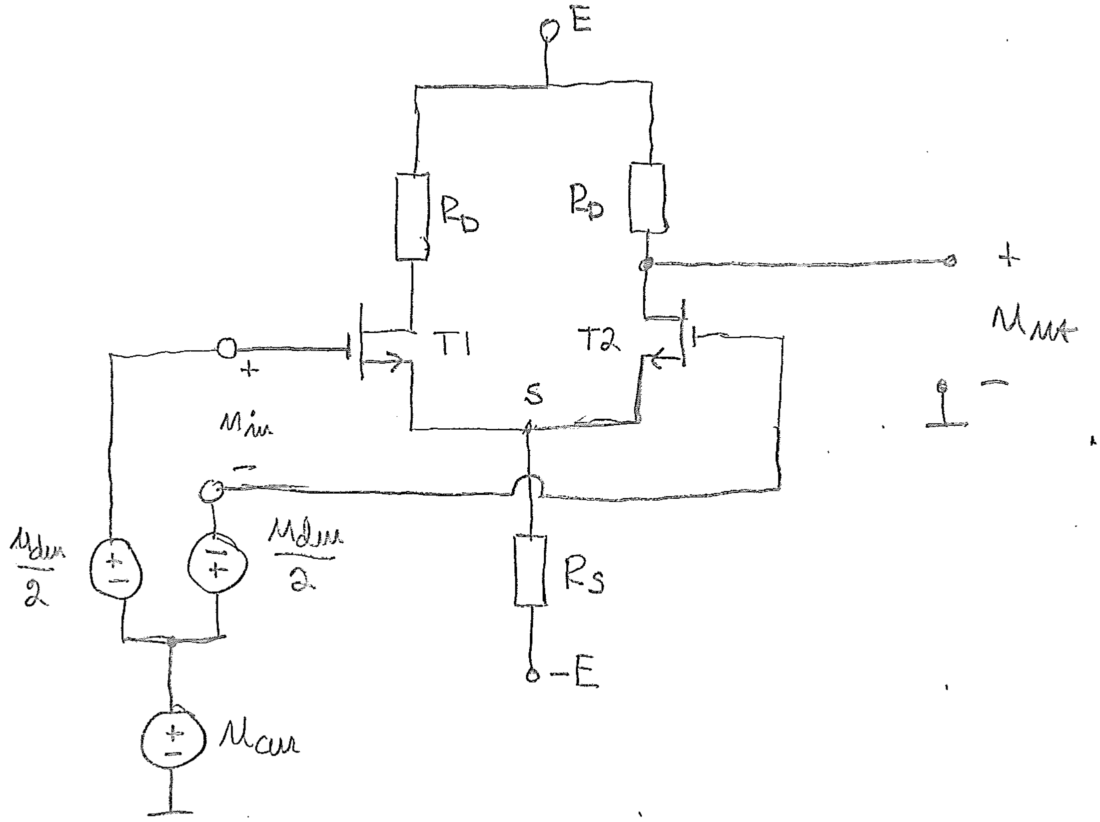
$$v_B = -\frac{R_2}{R_1} \cdot u_{in} \quad (1)$$

<u>B</u>: $\dfrac{v_B - v_A}{R_2} + \dfrac{v_B - u_{ut}}{R_3} + \dfrac{v_B}{R_4} = 0 \; ; \quad v_A = 0 \Rightarrow$

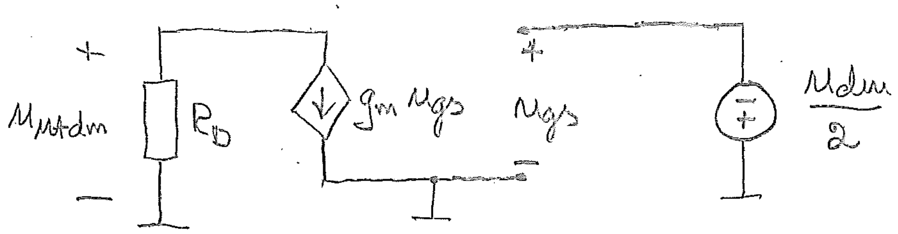
$$u_{ut} = \left(1 + \frac{R_3}{R_2} + \frac{R_3}{R_4}\right) \cdot v_B = -\frac{R_2}{R_1} \cdot \left(1 + \frac{R_3}{R_2} + \frac{R_3}{R_4}\right) \Rightarrow$$

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

3 Betrakta T2 för DM- och CM-signaler



DM: $u_{cm} = 0$. Småsignalschema
$v_S = 0$

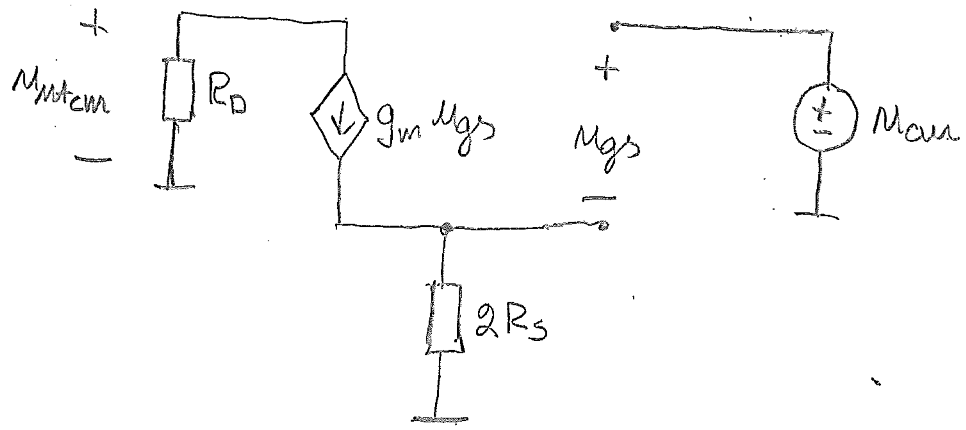


$$u_{ut\text{-}dm} = -g_m u_{gs} \cdot R_D$$

$$u_{gs} = -\frac{u_{dm}}{2} \Rightarrow u_{ut} = g_m R_D \cdot \frac{u_{dm}}{2} \Rightarrow$$

$$A_{dm} = \frac{u_{ut\text{-}dm}}{u_{dm}} = \frac{g_m R_D}{2} = \underline{40 \text{ ggr}}$$

CM : $u_{dm} = 0$



$$u_{utcm} = -g_m u_{gs} \cdot R_D$$

$$u_{cm} = u_{gs} + g_m u_{gs} \cdot 2R_S = (1 + 2g_m R_S) \cdot u_{gs} \Rightarrow$$

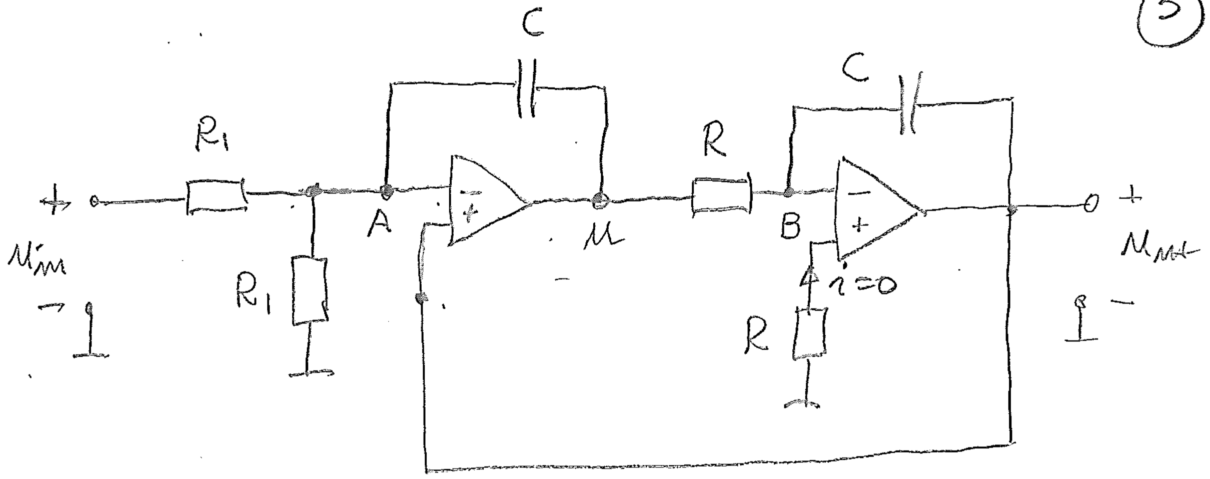
$$u_{utcm} = -\frac{g_m R_D}{1 + 2g_m R_S} \cdot u_{cm} \Rightarrow$$

$$A_{cm} = \frac{u_{utcm}}{u_{cm}} = -\frac{g_m R_D}{1 + 2g_m R_S} = -0{,}729 \Rightarrow$$

$$CMRR = \left| \frac{A_{dm}}{A_{cm}} \right| = \underline{\underline{54{,}9 \text{ ggr}}} = \underline{\underline{34{,}8 \text{ dB}}}$$

4

5



Ideala motkopplade OP $\Rightarrow$
- inströmmar = 0
- lika potential på ingångarna.

$$\Rightarrow v_A = u_{ut} \quad , \quad v_B = 0$$

Nodanalys:

A
$$\frac{v_A - u_{in}}{R_1} + \frac{v_A}{R_1} + \frac{v_A - u}{1/sC} = 0 \quad ; \quad v_A = u_{ut} \Rightarrow$$

$$(2 + sR_1C)\cdot u_{ut} = sR_1C\cdot u + u_{in} \qquad (1)$$

B
$$\frac{v_B - u}{R} + \frac{v_B - u_{ut}}{1/sC} = 0 \quad ; \quad v_B = 0 \Rightarrow$$

$$u = -sRC\cdot u_{ut} \quad (2) \quad ; \quad \text{Sätt in i } (1)$$

$$(2+sR_1C)\cdot u_{ut} = -s^2RR_1C^2 + u_{in} \Rightarrow$$

$$\frac{u_{ut}}{u_{in}} = \frac{1}{s^2RR_1C^2 + sR_1C + 2} = \frac{1}{RR_1C^2}\cdot\frac{1}{s^2 + \frac{1}{RC}\cdot s + \frac{2}{RR_1C^2}}$$

Poler: $s^2 + \frac{1}{RC}\cdot s + \frac{2}{RR_1C^2} = 0 \Rightarrow$

$$s = -\frac{1}{2RC} \pm \sqrt{\underbrace{\frac{1}{4R^2C^2} - \frac{2}{RR_1C^2}}_{<0}}$$

Maximalt snabbt utan översväng $\Rightarrow$

$$\frac{1}{4R^2C^2} = \frac{2}{RR_1C^2} \Rightarrow R_1 = 8R = \underline{\underline{80k\Omega}}$$

Då gäller att

$$\frac{U_{ut}}{U_{in}} = \frac{1}{RR_1C^2} \cdot \frac{1}{\left(s+\frac{1}{2RC}\right)^2} = 56{,}6 \cdot 10^6 \cdot \frac{1}{(s+10638)^2} =$$

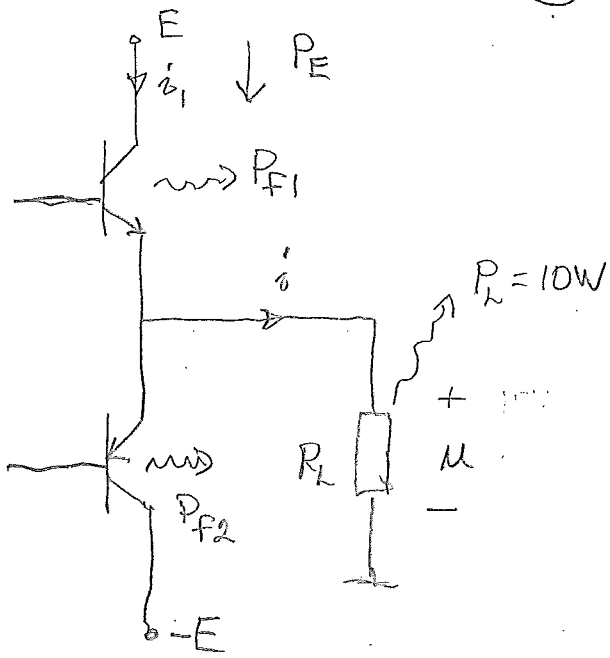
$$= \frac{0{,}5}{\left(1+\frac{s}{10638}\right)^2} \quad . \text{ Dubbelpol } s = -10638 \Rightarrow$$

$$\omega_{\text{ÖTOT}} = 10638\,\text{rad/s} \cdot \sqrt{2^{1/2}-1} = 6847\,\text{rad/s} \Rightarrow$$

övre gränsfrekvens $f_ö = \frac{6847}{2\pi}\,\text{Hz} = 1089{,}7\,\text{Hz}$

$\Rightarrow$ Stigtiden $t_r = \frac{0{,}35}{f_ö} = \underline{\underline{0{,}32\,\text{ms}}}$

5) $R_L = 4\Omega$; $E = 12V$



$$P_L = R_L \cdot \frac{\hat{i}^2}{2} \Rightarrow$$

$$\hat{i} = \sqrt{\frac{2P_L}{R_L}} = \sqrt{\frac{2 \cdot 10W}{4\Omega}} = \underline{2{,}24A}$$

$$\Rightarrow \hat{i}_1 = 2{,}24A \Rightarrow$$

$$P_{in} = 2P_E = 2 \cdot E \cdot \bar{i}_1 = 2 \cdot 12V \cdot \frac{2{,}24A}{\pi} = \underline{17{,}08W} \Rightarrow$$

$$\eta = \frac{P_L}{P_{in}} = 0{,}585 = \underline{\underline{58{,}5\%}}$$

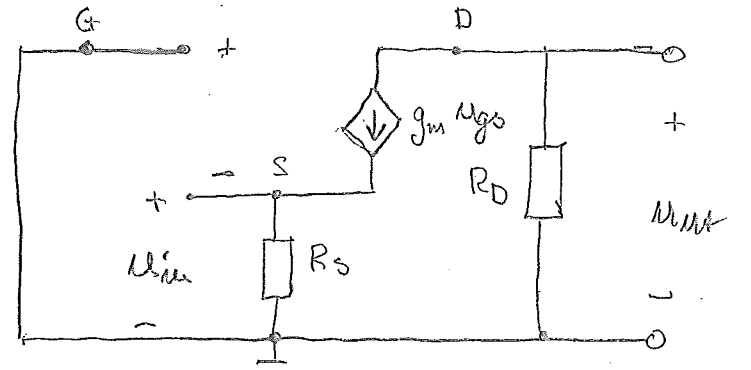
Transistorförlusterna $P_F = P_{F1} + P_{F2} = P_{in} - P_L = \underline{\underline{7{,}08W}}$

Maximal effekt i R_L erhålles då transistorerna bottnar, dvs då $u_{ce1min} = u_{ce2min} = 0$.

Då gäller att $\hat{u} = E = 12V$, vilket ger

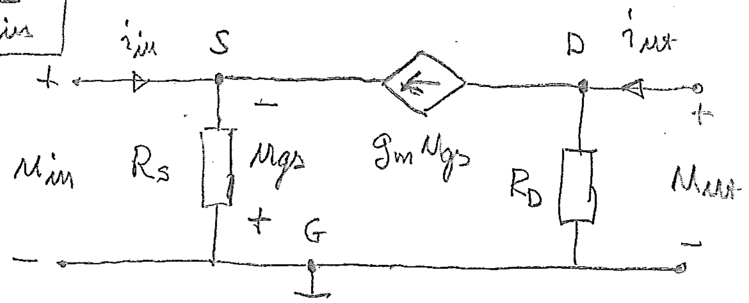
$$P_{Lmax} = \frac{\frac{\hat{u}^2}{2}}{R_L} = \frac{E^2}{2R_L} = \frac{(12V)^2}{2 \cdot 4\Omega} = \underline{\underline{18W}}$$

6a Småsignalschema



$\Longleftrightarrow$

$\boxed{\dfrac{u_{ut}}{u_{in}}}$



$R_S = 3{,}3\,k\Omega$
$R_D = 4{,}7\,k\Omega$
$g_m = 10\,mA/V$

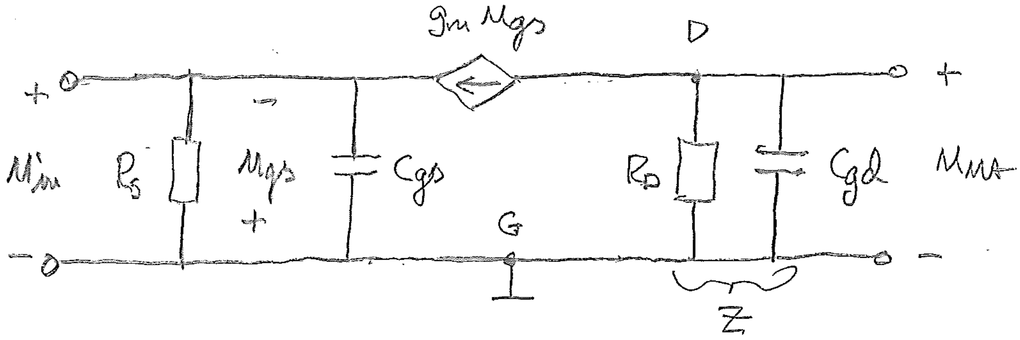
- $u_{ut} = -g_m u_{gs} \cdot R_D$; $u_{gs} = -u_{in} \Rightarrow$
- $u_{ut} = g_m R_D \cdot u_{in} \Rightarrow \dfrac{u_{ut}}{u_{in}} = g_m R_D = \underline{\underline{47\text{ ggr}}}$

$\boxed{R_{in}}$ $R_{in} = \left.\dfrac{u_{in}}{i_{in}}\right|_{i_{ut}=0}$

- $u_{in} = R_S \cdot (i_{in} + g_m u_{gs})$; $u_{gs} = -u_{in} \Rightarrow$
- $u_{in} = R_S \cdot i_{in} - R_S \cdot g_m u_{in} \Rightarrow$

$$R_{in} = \frac{u_{in}}{i_{in}} = \frac{R_S}{1+g_m R_S} = \underline{\underline{97{,}1\,\Omega}}$$

6b. Småsignalschema



$u_{ut} = -g_m u_{gs} \cdot Z \quad ; \quad u_{gs} = -u_{in} \Rightarrow$

$u_{ut} = -g_m (-u_{in}) \cdot Z = g_m Z \cdot u_{in} \Rightarrow$

$$\frac{u_{ut}}{u_{in}} = g_m Z = g_m \cdot \frac{R_D \cdot \frac{1}{sC_{gd}}}{R_D + \frac{1}{sC_{gd}}} = \frac{g_m R_D}{1 + sR_D C_{gd}} =$$

$$= \frac{47}{1 + \frac{s}{53{,}2 \cdot 10^6}} \Rightarrow$$

$$f_{ö} = \frac{53{,}2 \cdot 10^6}{2\pi}\ \text{Hz} = \underline{\underline{8{,}47\ \text{MHz}}}$$