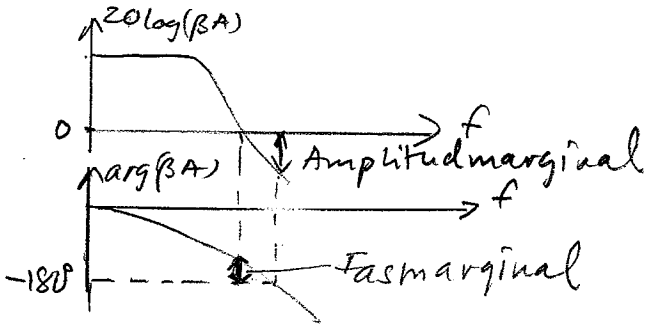
Svar till tenta Elektronik forts. 14/1-04

A1. -60dB/dekad

A2.



A3. Max I_Z då I_{R_L} är min. $\left(\frac{10}{100}=0{,}1A\right)$ och V_{IN} är max

$$\frac{V_{IN,max}-10V}{R} = I_{R_L,min} + I_{Z,max}$$

$$I_{Z,max} = \frac{P_{Z,max}}{10V} = \frac{2}{10} = 0{,}2A$$

$$\Rightarrow \frac{V_{IN,max}}{50\Omega} = \frac{10V}{50\Omega} + 0{,}1A + 0{,}2A = 0{,}5A$$

$$\Rightarrow V_{IN,max} = 50 \cdot 0{,}5 = \underline{\underline{25V}}$$

$I_Z = 0$ då $V_{IN,min}$ och $I_{R_L,max}$

$$\frac{V_{IN,min}-10V}{50\Omega} = \frac{10}{50} \Rightarrow V_{IN,min} = \underline{\underline{20V}}$$

A4. Spän. delning på utgången

$$V_{ZK} = V_{out}\frac{R_2}{R_1+R_2} \Rightarrow V_{out} = \underline{\underline{18V}}$$

A5.

$$I_{C5} = \frac{2V_{CC}-2V_{BE}}{R} = \frac{2\cdot 11{,}3V}{15k\Omega} \approx 1{,}5mA \approx I_{C4}$$

$$I_{C2} = I_{C3} \approx \frac{I_{C4}}{2} = \underline{\underline{0{,}75mA}}$$

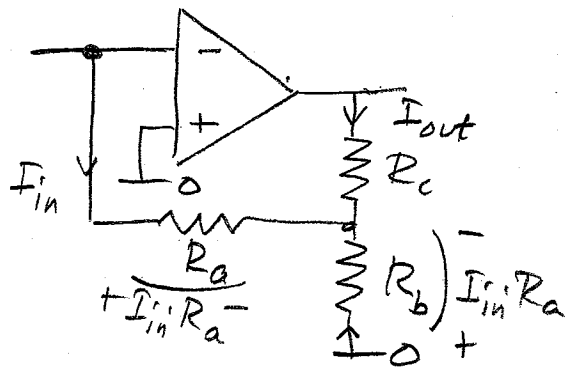
A6. $f_{out} = n \cdot f_{in}$

A7.

$$f_L = \frac{1}{2\pi R_1 C} \approx \underline{\underline{7{,}2Hz}}$$

A8. a) c) och f)

A9.



Kirch. strömlag

$$I_{in} + I_{out} + \frac{I_{in} R_a}{R_b} = 0$$

$$\Rightarrow \frac{I_{out}}{I_{in}} = -\left(1 + \frac{R_a}{R_b}\right)$$

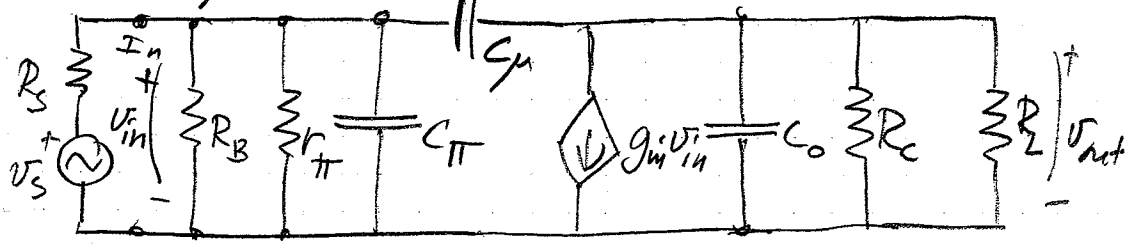
A10.

$$\left(\frac{V_{ref}}{2R} + \frac{V_{ref}}{16R}\right) \cdot 4R = -V_{out}$$

$$\Rightarrow V_{ref}\left(2 + \frac{1}{4}\right) = 5 \cdot 2{,}25 = +11{,}25\,V = -V_{out}$$

$\therefore V_{out} = -11{,}25\,V$

B1. Ekv. signalschema



$$f_T = \frac{\beta}{2\pi r_\pi (C_\mu + C_\pi)} \Rightarrow C_\mu + C_\pi = \frac{\beta}{f_T \cdot 2\pi r_\pi} =$$

$$= \frac{200}{200 \cdot 10^6 \cdot 2\pi \cdot 23 \cdot 10^3} = 69{,}2\,pF \Rightarrow C_\pi = 66{,}2\,pF$$

$$C_{in,miller} = C_\mu (1 - A_v)$$

$$A_v = -g_m \cdot R_L' = -\frac{\beta}{r_\pi} \cdot (R_c \| R_L) = -208{,}7 \approx 99$$

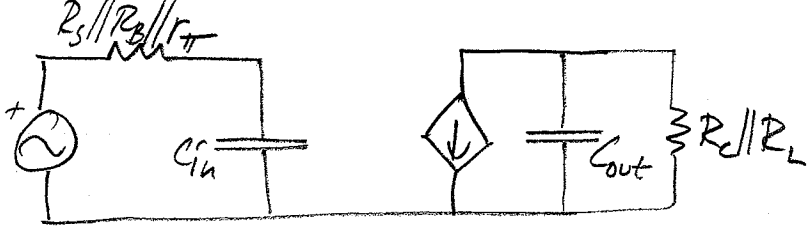
$$\Rightarrow C_{in,miller} = 3pF(1 + 208{,}7) = 629{,}1\,pF$$

$$C_{in} = C_{in,miller} + C_\pi = 629{,}1 + 66{,}2 = 695{,}3\,pF$$

$$C_{out} = C_o + C_{out,miller} = C_o + C_\mu \frac{A_v - 1}{A_v} =$$

$$= 5 + 3\,\frac{-209{,}7}{-208{,}7} \approx 8\,pF$$

Förenklat ekv. signalschema



$$f_{H,in} = \frac{1}{2\pi (R_S \| R_B \| r_\pi) \cdot C_{in}} = \frac{1}{2\pi \cdot 1{,}57 \cdot 10^3 \cdot 695{,}3 \cdot 10^{-12}}$$

$$= \underline{146\ kHz}$$

$$f_{H,out} = \frac{1}{2\pi \cdot 2{,}4 \cdot 10^3 \cdot 8 \cdot 10^{-12}} = \underline{8{,}3\ MHz}$$

$$f_{H,tot} = \frac{1}{\frac{1}{f_{H,in}} + \frac{1}{f_{H,out}}} \approx \underline{143\ kHz}$$

B2.

$$A_V = \frac{R_2 \| (R_3 + \frac{1}{sC}) + R_1}{R_1} = \frac{\frac{R_2(R_3+\frac{1}{sC})}{R_2+R_3+\frac{1}{sC}} + R_1}{R_1} =$$

$$= \frac{R_2(R_3+\frac{1}{sC}) + R_1(R_2+R_3+\frac{1}{sC})}{R_1(R_2+R_3+\frac{1}{sC})} =$$

$$= \frac{R_2R_3 + R_2\frac{1}{sC} + R_1R_2 + R_1R_3 + R_1\frac{1}{sC}}{R_1R_2 + R_1R_3 + R_1\frac{1}{sC}} \cdot \frac{sC}{sC} =$$

$$= \frac{(R_2R_3 + R_1R_2 + R_1R_3)\cdot sC + (R_1+R_2)}{(R_1R_2 + R_1R_3)\cdot sC + R_1}$$

Nollställe: $(R_2R_3 + R_1R_2 + R_1R_3)\cdot sC + R_1 + R_2 = 0$

$$\Rightarrow s = -\frac{R_1+R_2}{(R_2R_3 + R_1R_2 + R_1R_3)C} \Rightarrow \omega_n = 2453\ rad/s$$

$$\Rightarrow f_n = \underline{390\ Hz}$$

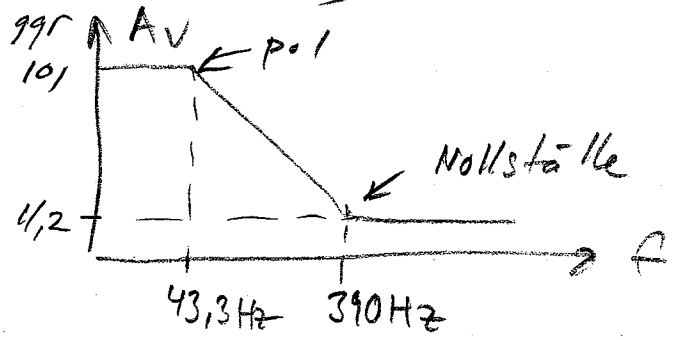
Pol: $(R_1R_2 + R_1R_3)\cdot sC + R_1 = 0$

$$\Rightarrow s = -\frac{R_1}{(R_1R_2 + R_1R_3)\cdot C} \Rightarrow \omega_n = 272\ rad/s$$

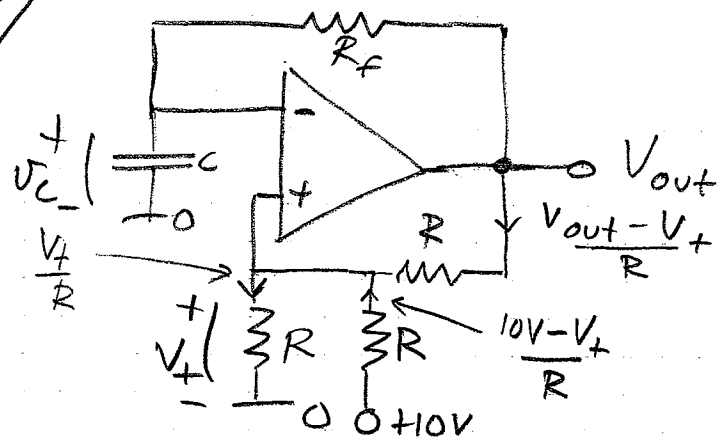
$$\Rightarrow f_p = \underline{43\ Hz}$$

forts.
B2/ $A_V = \frac{R_2 // R_3 + R_1}{R_1} = 11{,}2$ ggr då $f \to \infty$ (Kondensator är kortslutning)

$A_V = \frac{R_2 + R_1}{R_1} = 101$ ggr då $f \to 0$ (Kondensatorn är avbrott)



B3/



Kirch. strömlag

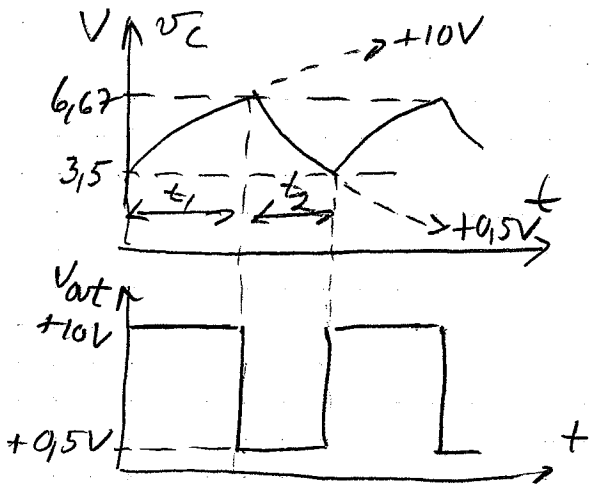
$\frac{V_{out}-V_+}{R} + \frac{10V-V_+}{R} = \frac{V_+}{R}$

$\Rightarrow V_+ = \frac{V_{out}+10V}{3}$

Omslag då $v_C = V_+ = \frac{V_{out}+10V}{3}$

$\Rightarrow V_{out} = 10V \Rightarrow V_+ = \frac{20}{3} = 6{,}67V$

$\Rightarrow V_{out} = 0{,}5V \Rightarrow V_+ = \frac{10{,}5}{3} = 3{,}5V$



$\Delta t = \tau \ln \frac{A}{B}$ ger

$t_1 = R_f C \ln \frac{10-3{,}5}{10-6{,}67} = 20\,\mu s$

$t_2 = R_f C \ln \frac{6{,}67-0{,}5}{3{,}5-0{,}5} = 21{,}6\,\mu s$

$f = \frac{1}{t_1+t_2} = \underline{24\,kHz}$

B4/ Total termisk resistans $\Theta_{tot} = 1{,}5 + 3 + 0{,}5 = 5\ ^\circ C/W$

Kollektorförlusten $P_{D,max} = \frac{T_J - T_A}{\Theta_{tot}} = \frac{175-35}{5} =$

$= \underline{28W}$ (en transistor)

för båda transistorna gäller:

$$P_D = \frac{2 \cdot V_{CC} \cdot V_m}{\pi (R_L + R_E)} - \frac{V_m^2}{2(R_L + R_E)} \quad \left(= P_{Batt} - P_{Last} \right)$$

Derivering för att få $P_{D,max}$

$$\frac{dP_D}{dV_m} = \frac{2 \cdot V_{CC}}{\pi (R_L + R_E)} - \frac{2 \cdot V_m}{2(R_L + R_E)} = 0$$

$$\Rightarrow V_m = \frac{V_{CC} \cdot 2}{\pi}$$

$$\therefore P_{D,max} = \frac{2 \cdot V_{CC} \cdot V_{CC} \cdot 2}{\pi (R_L + R_E) \pi} - \frac{\left(\frac{V_{CC} \cdot 2}{\pi}\right)^2}{2(R_L + R_E)} = \frac{V_{CC}^2 \cdot 2}{\pi^2 (R_L + R_E)}$$

$$\therefore 2 \cdot 28W = \frac{30^2 \cdot 2}{\pi^2 (R_L + R_E)} \Rightarrow R_L + R_E = 3{,}26\,\Omega$$

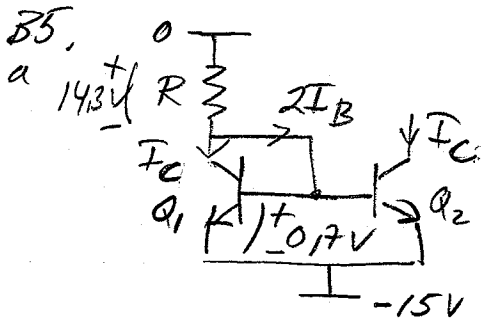
$$\Rightarrow R_L = 2{,}76 - 0{,}5 = \underline{2{,}76\,\Omega}$$

$$\hat{I}_{out,max} = \frac{30 - 3}{R_E + R_L} = \frac{27}{3{,}26} = 8{,}28\,A$$

$$P_{out,max} = \frac{1}{2} \cdot \hat{I}_{out,max}^2 \cdot R_L = \frac{8{,}28^2 \cdot 2{,}76}{2} \approx \underline{95W}$$

B5.

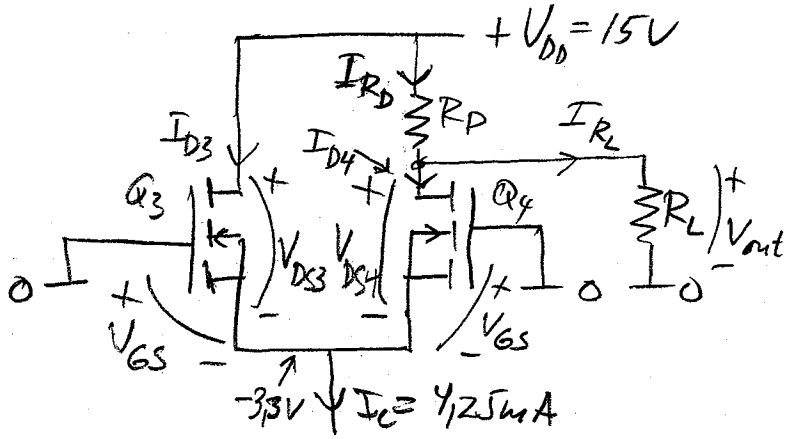
a



$$(I_C + 2I_B)\cdot R = 14{,}3\,V$$

$$\Rightarrow \left(I_C + 2\frac{I_C}{\beta}\right)\cdot 3{,}3\,k\Omega = 14{,}3\,V$$

$$\Rightarrow I_C = 4{,}25\,mA$$



$$I_{D3} = I_{D4} = \frac{4{,}25}{2} = 2{,}12\,mA$$

$$I_{D3} = I_{D4} = K\cdot(V_{GS} - V_{to})^2 =$$

$$= \frac{1}{2} KP \frac{W}{L}(V_{GS} - V_{to})^2 =$$

$$= 1{,}25\,mA/V^2 (V_{GS} - 2)^2 = 2{,}12\,mA$$

$$\Rightarrow V_{GS} = 3{,}3\,V$$

$$V_{DS3} = 15 + 3{,}3 = 18{,}3\,V$$

$$18{,}3\,V = I_{R_D}\cdot R_D + V_{DS4}$$

Kirch. Stromlaw

$$I_{R_D} = I_{R_L} + I_{D4} = I_{R_L} + 2{,}12\,mA$$

$$\Rightarrow 18{,}3\,V = (I_{R_L} + 2{,}12\,mA)R_D + V_{DS4}$$

$$\text{dar } I_{R_L} = \frac{3{,}3\,V + V_{DS4}}{R_L} = \frac{3{,}3}{10}\,mA + \frac{V_{DS4}}{10k\Omega}$$

$$\Rightarrow 18{,}3\,V = \left(0{,}33\,mA + \frac{V_{DS4}}{10k\Omega}\right)\cdot 6{,}8\,k\Omega + V_{DS4}$$

$$\Rightarrow V_{DS4} = 3{,}63\,V$$

b) $$A_{vds} = -\frac{1}{2} g_m \cdot (r_d \| R_D \| R_L) \quad \text{dar } g_m = 2\sqrt{K\cdot I_{D4}} =$$

$$= 2\cdot\sqrt{1{,}25\cdot 2{,}12} = 3{,}26\,mA/V$$

$$\Rightarrow A_{vds} = -\frac{1}{2}\cdot 3{,}26\cdot(50\|6{,}8\|10) = -6{,}199$$

c) $$CMRR_s = \frac{1}{2} + g_m R_{SB} = \frac{1}{2} + g_m r_0 = \frac{1}{2} + 3{,}26\cdot 150$$

$$\approx 490\ 99r$$