Tenta måndag 16/8-04, Elektronik AK.

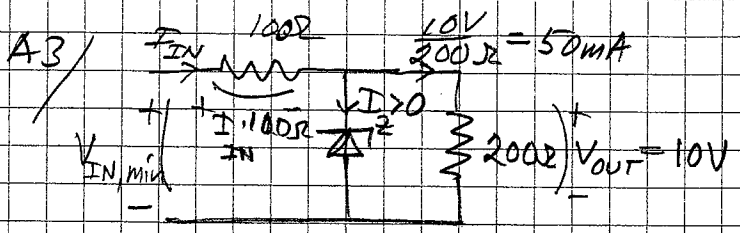
A1/ Efter pol 1 — -20dB/dekad

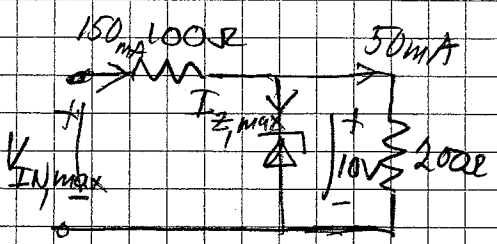
" pol 2 — -40dB/dekad

" pol 3 — -60dB/dekad

A2/ $\arg \beta A = 0$ och $|\beta A| = 1$

A3/





$I_{IN} > 50mA$

$V_{IN,min} = 50mA \cdot 100\Omega + 10V =$

$= 15V$

$\therefore V_{rippel} = \underline{5V}$

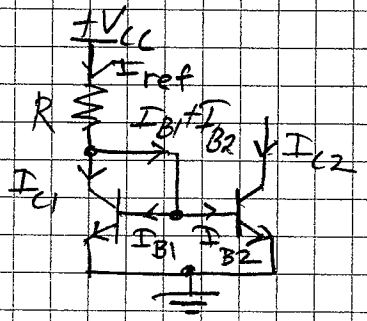
$I_{Z,max} = \frac{1W}{10V} =$

$= 100mA$

$\therefore V_{IN,max} = 150mA \cdot 100 +$

$+ 10V = 25V$

A4/



$I_{ref} = I_{C1} + I_{B1} + I_{B2}$

Transistorerna lika

$I_{C1} = I_{C2}$ och $I_{B1} = I_{B2}$

$\Rightarrow I_{ref} = \beta \cdot I_{B1} + I_{B1} + I_{B1} =$

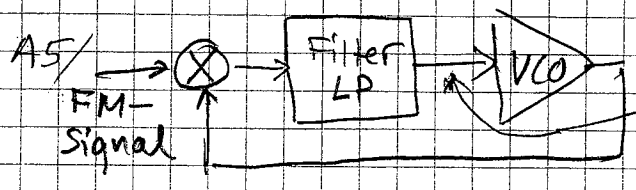
$= (\beta+2) \cdot I_{B1} = \frac{V_{CC} - V_{BE}}{R} =$

$= \frac{5V - 0,7V}{12k\Omega} = \frac{4,3V}{12k\Omega}$

$\Rightarrow I_{C2} = \frac{\beta}{\beta+2} \cdot \frac{4,3V}{12k\Omega} = 0,3445mA$

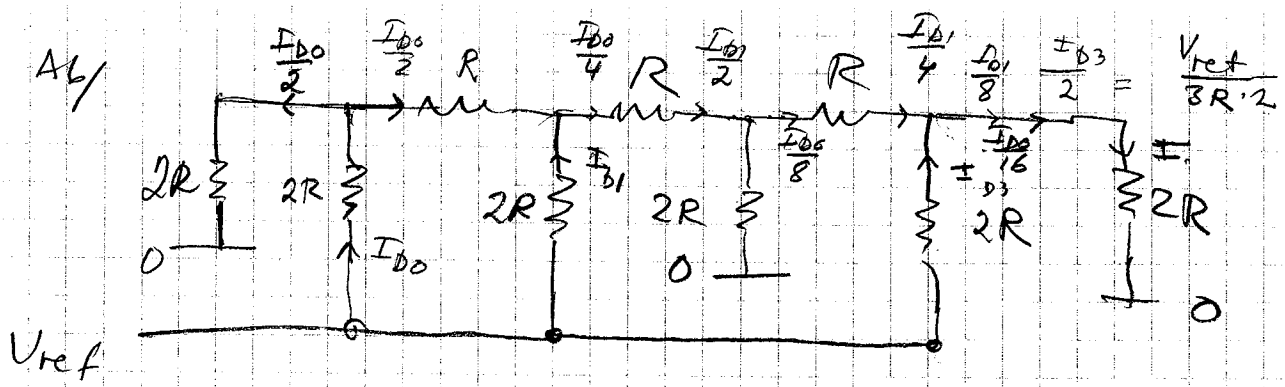
då $\beta = 50$ och $0,3583mA$ då $\beta \to \infty$ $\therefore$ skillnad $\underline{0,014mA}$

A5/



Lågfrekventa signalen från LP-filtret ändrar VCO:ns frekvens i takt med FM-signalen.

A6/



$$I = \frac{I_{D3}}{2} + \frac{I_{D1}}{8} + \frac{I_{D0}}{16} = \frac{V_{ref}}{3R}\left(\frac{1}{2} + \frac{1}{8} + \frac{1}{16}\right)$$

$$I_{D0} = I_{D1} = I_{D3} = \frac{V_{ref}}{3R}$$

$$V_{in} = I \cdot 2R = \frac{V_{ref} \cdot 2R}{3R}\left(\frac{1}{2} + \frac{1}{8} + \frac{1}{16}\right) =$$

$$= \frac{10 \cdot 2}{3}\left(\frac{1}{2} + \frac{1}{8} + \frac{1}{16}\right) = \underline{4{,}58\ V}$$

A7/ $f_{uq} = \frac{1}{2\pi C \cdot R_1} = \frac{1}{2\pi \cdot 120 \cdot 10^{-9} \cdot 56 \cdot 10^3} = \underline{23{,}7\ Hz}$

A8/ $C_p = 12{,}000\ pF$ $f_s = 5{,}000\ MHz$, $R_s = 50\Omega$

$Q = 20000$ Solut: f_p

$$f_p = \frac{1}{2\pi\sqrt{C_{eq} \cdot L_s}} \qquad Q = \frac{\omega_s L_s}{R_s} \Rightarrow L_s = \frac{R_s \cdot Q}{\omega_s} =$$

$$= \frac{50 \cdot 20000}{2\pi \cdot 5 \cdot 10^6}$$

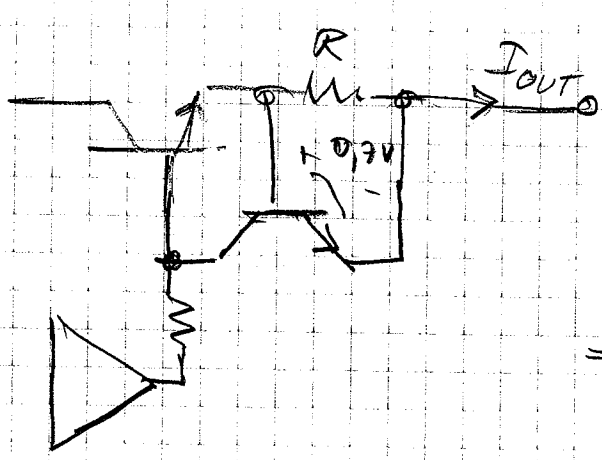
$$\begin{cases} \frac{1}{C_{eq}} = \frac{1}{C_s} + \frac{1}{C_p} = \omega_s^2 L_s + \frac{1}{C_p} \\ \omega_s^2 = \frac{1}{L_s \cdot C_s} \Rightarrow C_s = \frac{1}{\omega_s^2 \cdot L_s} \end{cases}$$

$$f_p = \frac{1}{2\pi\sqrt{\frac{1}{\omega_s^2 L_s + \frac{1}{C_p}} \cdot L_s}} = \frac{1}{2\pi} \cdot \sqrt{\frac{\omega_s^2 L_s + \frac{1}{C_p}}{L_s}} =$$

$$= \frac{1}{2\pi} \cdot \sqrt{\omega_s^2 + \frac{1}{L_s C_p}} = \frac{1}{2\pi}\sqrt{\omega_s^2 + \frac{\omega_s}{R_s Q \cdot C_p}}$$

$$= \frac{1}{2\pi}\sqrt{(2\pi \cdot 5 \cdot 10^6)^2 + \frac{2\pi 5 \cdot 10^6}{50 \cdot 20000 \cdot 12 \cdot 10^{12}}} = \underline{5{,}0066\ MHz}$$

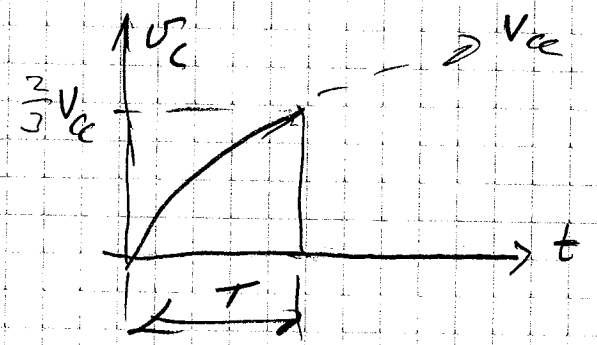
A9/



$$I_{OUT,max} = \frac{0,7V}{R} = 2A$$

$$\Rightarrow R = \underline{0,35\Omega}$$

A10/



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

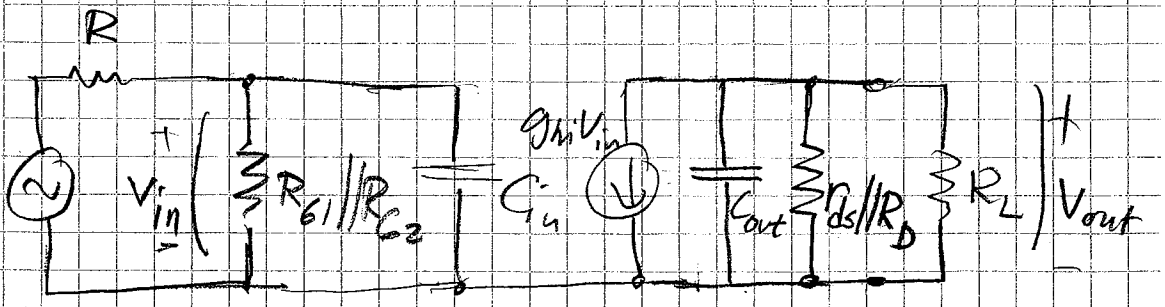
ger

$$T = R_A \cdot C \ln \frac{V_{cc}}{\frac{1}{3}V_{cc}}$$

$$= 12 \cdot 10^3 \cdot 10 \cdot 10^{-9} \ln 3 =$$

$$= \underline{0,132\ ms}$$

B1/



$$\begin{cases} C_{in} = C_{gs} + (1 - A_V) \cdot C_{gd} \\ C_{out} = C_{ds} + \dfrac{A_V - 1}{A_V} \cdot C_{gd} \end{cases}$$

$$g_m = 2\sqrt{I_{DQ} \cdot K} \qquad A_V = -g_m \cdot (R_D // r_{ds} // R_L)$$

$$f_{tg,in} = \frac{1}{2\pi (R_{G1} // R_{G2} // R) \cdot C_{in}}$$

$$f_{tg,out} = \frac{1}{2\pi (R_D // r_{ds} // R_L) \cdot C_{out}}$$

$$g_m = 2\sqrt{2,2 \cdot \frac{8}{2,5^2}} = \frac{2}{2,5}\sqrt{22,8} = 3,356 \text{ mA/V}$$

$$K = \frac{I_{DSS}}{V_{to}^2} = \frac{8}{2,5^2}$$

$$R_D // r_{ds} // R_L = 5 // 100 // 12 = 3,409 \text{ k}\Omega$$

$$A_V = -3,356 \cdot 3,409 = -11,4499$$

$$C_{in} = 3,5 + (11,44 + 1) \cdot 1 = 15,94 \text{ pF}$$

$$R_{G1} // R_{G2} // R = 1,5 \text{ M}\Omega // 0,68 \text{ M}\Omega // 100 \text{ k}\Omega = 82,39 \text{ k}\Omega$$

$$f_{tg,in} = \frac{1}{2\pi \, 82,39 \cdot 10^3 \cdot 15,94 \cdot 10^{-12}} = \underline{121,2 \text{ kHz}}$$

Aufg 3

B1)

$r_{ds} // R_D // R_L = 180\,k\Omega // 5\,k\Omega // 12\,k\Omega = 3{,}41\ k\Omega$

$C_{out} = C_{ds} + C_{gd}\,\frac{A_v - 1}{A_v} = 1{,}2 + \frac{-1{,}44 - 1}{-1{,}44} \cdot 1$

$= 2{,}2874\ pF$

$f_{g,out} = \frac{1}{2\pi \cdot 3{,}41 \cdot 10^3 \cdot 2{,}287 \cdot 10^{-12}} =$

$= \underline{20{,}4\,MHz}$

$\frac{1}{f_{g,tot}} = \frac{1}{f_{g,in}} + \frac{1}{f_{g,out}} = \frac{1}{121{,}2\,kHz} + \frac{1}{20{,}4\,MHz}$

$f_{g,tot} = \underline{\underline{120{,}5\ kHz}}$

B2)

$\frac{U_{out}}{U_{in}} = -\frac{R_2}{R_3 // (R_1 + \frac{1}{j\omega C})} = -$

$= -\frac{R_2}{\frac{R_3 (R_1 + \frac{1}{j\omega C})}{R_3 + R_1 + \frac{1}{j\omega C}}} = -\frac{R_2 (R_1 + R_3 + \frac{1}{j\omega C})}{R_3 (R_1 + \frac{1}{j\omega C})}$

$= -\frac{R_2 (1 + j\omega C (R_1 + R_3))}{R_3 (1 + j\omega C \cdot R_1)}$

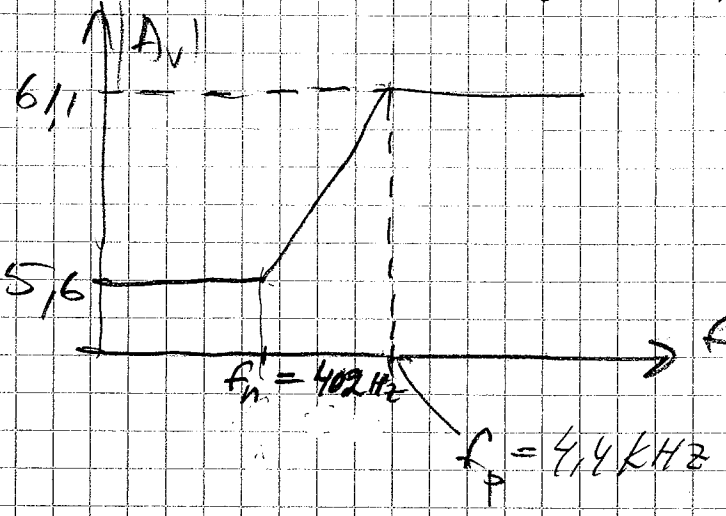
$f_p = \frac{1}{2\pi C R_1}$ ändert pol $f_p = \underline{4{,}42 \cdot 10^3\ Hz}$

$f_n = \frac{1}{2\pi C (R_1 + R_2)}$ ändert nulls falle

$f_n = \frac{1}{2\pi \cdot 20 \cdot 10^{-9} \cdot 19{,}8 \cdot 10^3} = \underline{402\ Hz}$

B2/ $|A_V|_{f\to 0} = \frac{R_2}{R_3} = \frac{100}{18} = 5,56$ ggr

$|A_V|_{f\to\infty} = \frac{R_2}{R_1 // R_3} = \frac{100}{1,8 // 18} = 61,1$ ggr



B3/ 2:a ordningens LP-filter

$A_V = \frac{\omega_0^2}{s^2 + s\frac{\omega_0}{Q} + \omega_0^2}$ $\omega_0 = \frac{1}{\sqrt{R_1 R_2 C_1 C_2}}$

$Q = \frac{\sqrt{R_1 R_2 C}}{\sqrt{C_2}(R_1 + R_2)}$

Poler:

$s_{1,2} = -\frac{\omega_0}{2Q} \pm \sqrt{\left(\frac{\omega_0}{2Q}\right)^2 - \omega_0^2}$

$\therefore \frac{\omega_0}{2Q} = 5\cdot 10^3$ och $\omega_0^2 - \left(\frac{\omega_0}{2Q}\right)^2 = (4\cdot 10^3)^2$

$\Rightarrow \omega_0^2 = (4\cdot 10^3)^2 + (5\cdot 10^3)^2 \Rightarrow \omega_0 = 6,4\cdot 10^3$ rad/s

$\therefore \frac{6,4\cdot 10^3}{2\cdot 5\cdot 10^3} = Q = 0,64$

$Q = \frac{R\sqrt{C_1}}{\sqrt{C_2}\cdot 2R} = 0,64$ $\omega_0 = \frac{1}{R\sqrt{C_1 C_2}} = 6,4\cdot 10^3$

$C_1 = C_2 \cdot 1,28^2$ $\Rightarrow C_1 C_2 = \left(\frac{1}{12\cdot 6,4\cdot 10^6}\right)^2$

forts

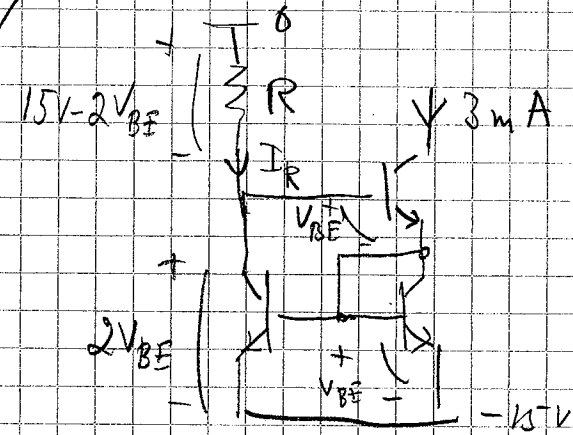
B3/

$$C_2 \cdot 1{,}28^2 \cdot C_2 = \left(\frac{1}{12 \cdot 6{,}4 \cdot 10^6}\right)^2$$

$$C_2 = \frac{10^{-6}}{1{,}28 \cdot 12 \cdot 6{,}4} = \underline{\underline{10{,}2\,nF}}$$

$$C_1 = C_2 \cdot 1{,}28^2 = 10{,}2 \cdot 1{,}28^2 = \underline{\underline{16{,}7\,nF}}$$

B4/



β stor ⇒

$$3mA = \frac{15V - 2 \cdot 0{,}7}{R}$$

$$R = \frac{13{,}6}{3} = \underline{\underline{4{,}53k\Omega}}$$

Bra tänka för Q_3 och Q_4

$$g_m = \frac{I_{CQ}}{V_T} = \frac{1{,}5mA}{0{,}026V} = 57{,}69\,mA/V$$

$$V_{out1} = -\frac{1}{2} g_m \cdot R_D (v_{in1} - v_{in2})$$

$$V_{out2} = +\frac{1}{2} g_m (R_D // R_2) \cdot (v_{in1} - v_{in2})$$

$$A_{vdb} = \frac{V_{out1} + V_{out2}}{V_{in1} - V_{in2}} = \frac{-\frac{1}{2} g_m (R_D + R_D // R_2) \cdot (v_{in1} - v_{in2})}{v_{in1} - v_{in2}}$$

$$= -\frac{1}{2} g_m (R_D + R_D // R_2) = -\frac{1}{2} 57{,}69 \cdot \left(10 + \frac{10 \cdot 20}{30}\right) =$$

$$= \underline{\underline{-481\ ggr}}$$

$$CMRR_S = \frac{r_\pi + (\beta+1) \cdot (R_{EF} + 2R_{EB})}{r_\pi + (\beta+1) R_{EF}}$$

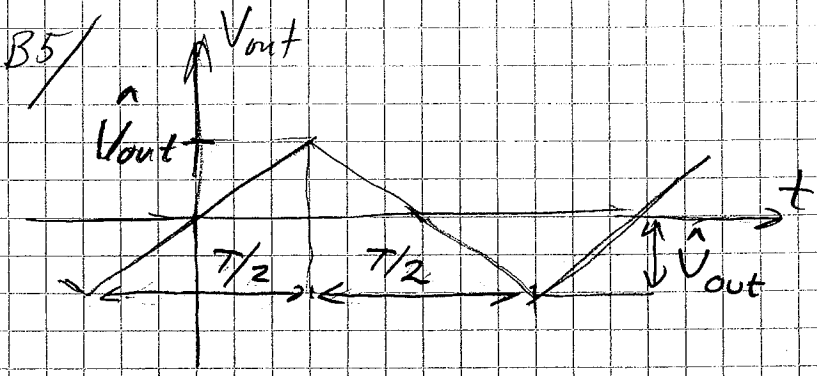
$R_{EF} = 0$ $R_{EB} = 2 \cdot r_o$ $r_\pi = \frac{\beta}{g_m} = \frac{250}{57{,}69} = 4{,}33k\Omega$

forts.

B4/ $CMRR_S = \dfrac{4{,}33k\Omega + 251 \cdot 2 \cdot 2 \cdot 150k\Omega}{4{,}33k\Omega + 0}$

$= 3{,}48 \cdot 10^4 = \underline{34{,}8 \cdot 10^3 \text{ ggr}}$ (90,8 dB)

B5/

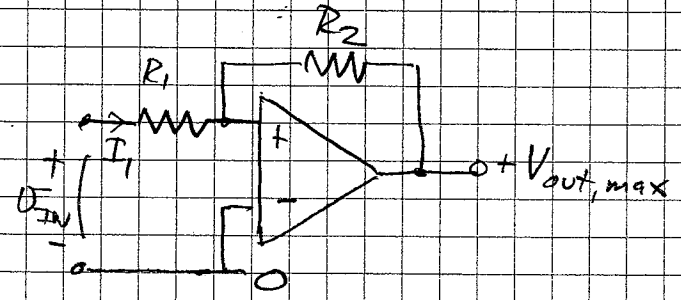


Integratorns utspänning

$$v_{out} = \mp \frac{1}{R_3 C} \cdot \int_0^t v_{in}\, dt = \pm \frac{1}{RC} \cdot V_{out,max}\, t$$

$$\hat{V}_{out} = \frac{1}{R_3 C} \cdot V_{out,max} \cdot \frac{T}{2} =$$

$$= \frac{1}{15 \cdot 10^3 \cdot 33 \cdot 10^{-9}} \cdot 10V \cdot \frac{T}{2}$$



Omslag då $U_- = 0$

$$I_1 = \frac{U_{IN}}{R_1} = \frac{-V_{out,max}}{R_2}$$

$$\Rightarrow U_{IN} = -\frac{R_1}{R_2} \cdot V_{out,max}$$

$$= -\frac{10}{27} \cdot 10 = \underline{-3{,}7V}$$

Om utspänning är $-V_{out,max}$
fås omslag då $U_{IN} = +3{,}7V$

$$\Rightarrow \hat{V}_{out} = 3{,}7V = \frac{1}{15 \cdot 10^3 \cdot 33 \cdot 10^{-9}} \cdot 10V \cdot \frac{T}{2}$$

$$\Rightarrow T = 3{,}67 \cdot 10^{-4} s \Rightarrow f = \frac{1}{T} = \underline{2{,}73 \text{ kHz}}$$