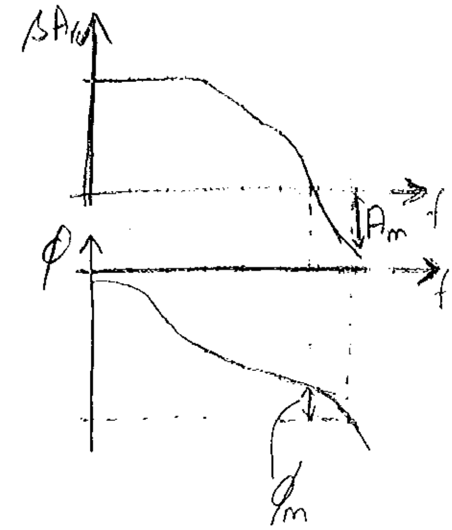
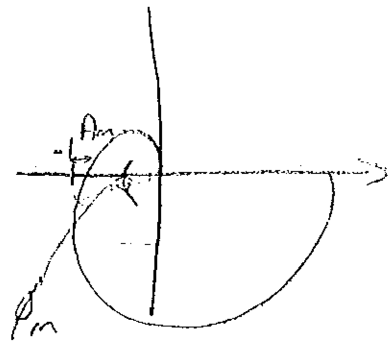
070110
Lösn

1. a) ⇒ Bättre linearitet
⇒ Mer okänslig för variationer i råförstärkning

b) ⇒ Kan leda till instabilitet

c)





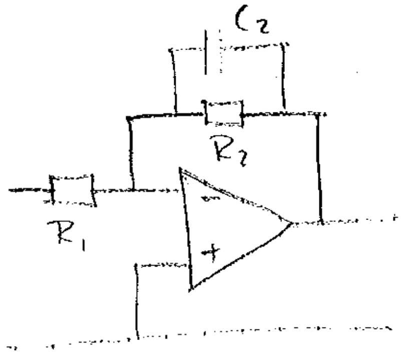
Amplitude margin, A_m: Hur mycket mindre än ett förstärkningen är vid 180° fasvridning

Fasmarginal, ϕ_m: Hur mycket mindre än 180° fasvridning då förstärkningen är 1.

d) Fasen

e) Vid låga förstärkningar

2)

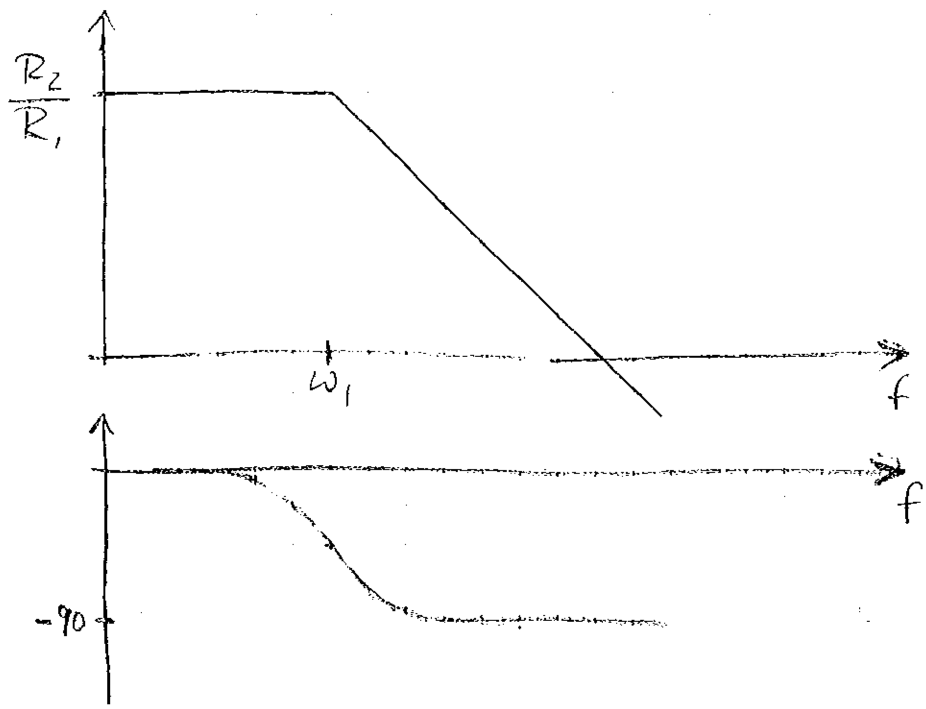


$$A_v = -\frac{Z_2}{Z_1}$$

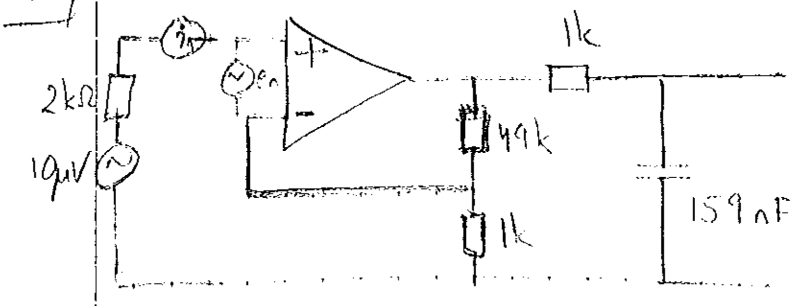
$$Z_2 = \frac{R_2 \cdot \frac{1}{j\omega C_2}}{R_2 + \frac{1}{j\omega C_2}} = \frac{R_2}{1+j\omega R_2 C_2}$$

$$A_v = -\frac{R_2}{R_1}\,\frac{1}{1+j\omega R_2 C_2} = -\frac{R_2}{R_1}\,\frac{1}{1+j\frac{\omega}{\omega_1}}$$

där $\omega_1 = \frac{1}{2\pi R_2 C_2}$



3)



Ingångsbrusspänning , $e_n = 5nV/\sqrt{Hz}$
Ingångsbrusström , $i_n = 2pA/\sqrt{Hz}$

Tot brus på ingången

$$e_{ntot} = \sqrt{e_n^2 + (R_g \cdot i_n)^2} = \sqrt{5n^2 + 4n^2} = \sqrt{25+16} = 6,4\,nV/\sqrt{Hz}$$

Förstärkning: $A_V = \frac{49k+1k}{1k} = 50$ ggr

Brusbandbredd: Bruset begränsas av filtret på utgången $f_g = \frac{1}{2\pi \cdot 1k \cdot 159n} = 1kHz$. Detta ger en brusbandbredd på $BW_N = f_g \cdot 1,57 = 1,57\,kHz$

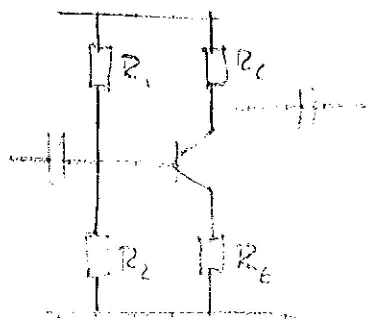
Tot brus $U_{Ntot} = e_{ntot} \cdot A_V \cdot \sqrt{BW_N} = 6,4n \cdot 50 \cdot \sqrt{1,57k} = 12,7\,\mu V$

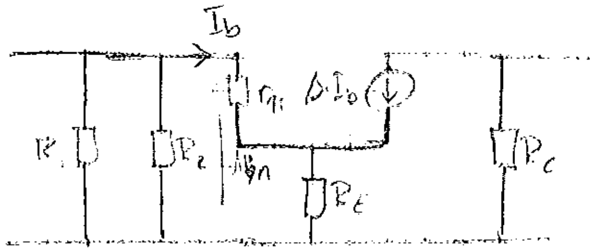
Tot signal $U_{sig} = U_{in} \cdot A_V = 10\mu \cdot 50 = 500\,\mu V$

$$SNR = 20 \log \frac{U_{sig}}{U_{Ntot}} = 20 \log \frac{500}{12,7} = 32\,dB$$

4

a)





b) $R_{in} = R_1 // R_2 // \frac{U_{in}}{I_b}$ $\quad U_{in} = I_b \cdot r_\pi + I_b(1+\beta) R_E \Rightarrow R_{in} = R_1 // R_2 // (r_\pi + R_E(1+\beta))$

$R_{out} = R_C$

$$A_v = \frac{U_{ut}}{U_{in}} = \frac{-\beta \cdot I_b \cdot R_C}{I_b r_\pi + I_b R_E(1+\beta)} = -\frac{\beta R_C}{r_\pi + R_E(1+\beta)} \approx -\frac{R_C}{\frac{r_\pi}{\beta} + R_E} \approx \frac{R_C}{R_E} \quad \text{då } R_E \gg \frac{r_\pi}{\beta}$$

c) $V_{CC} = 10\,V$, $A_v = 10$, $R_{out} \leq 1\,k\Omega$, $R_{in} > 10\,k\Omega$

$R_{out} \leq 1k \Rightarrow R_C = 1\,k\Omega$

$A_v = 10 \Rightarrow R_E = 100\,\Omega$

$\Rightarrow V_{CC} = 10\,V$ välj $V_{RCQ} = 4,5\,V$

$\Rightarrow I_{CQ} = \frac{4,5\,V}{1\,k\Omega} = 4,5\,mA$

$\Rightarrow V_{REQ} = I_{CQ} \cdot R_E = 4,5m \cdot 100 = 0,45\,V$

Datablad ger då: $\beta_{ac} = h_{fe} \approx 600$, $r_\pi = h_{ie} \approx 5\,k\Omega$

$\Rightarrow I_b = \frac{I_{CQ}}{\beta_{ac}} = \frac{4,5m}{600} = 7,5\,\mu A$

$U_{R_2} = U_{RE} + U_{BE} = 0,45 + 0,7 = 1,15\,V$

R_2 kommer att dominera R_{in} så välj $R_2 = 15\,k\Omega$

så hoppas vi att bidraget från R_1 o. R_E blir litet

$\Rightarrow I_{R_2} = \frac{U_{R2}}{R_2} = \frac{1,15}{15k} = 77\,\mu A$ i alla fall $10 \times I_B$

$$R_1 = \frac{U_{R_1}}{I_{R_2} + I_B} = \frac{10 - 1,15}{77\mu + 7,5\mu} = \frac{8,85}{84,5\mu} = 105\,k\Omega$$

$$R_{in} = R_1 // R_2 // \overbrace{r_\pi + R_E(1+\beta)}^{5k + 100 \cdot 600 = 65k} = \frac{1}{\frac{1}{15k} + \frac{1}{105k} + \frac{1}{65k}} = 10,9k > 10k$$ OK

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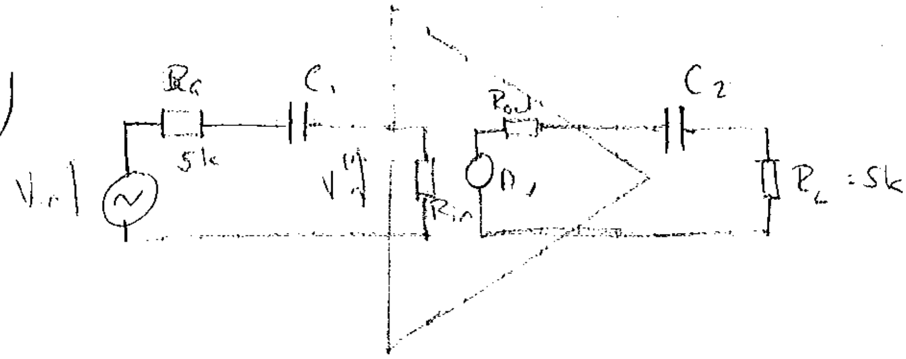
a)



b) $R_{in} = 10{,}9k \quad R_{out} = 1k$

$$V' = V_{in}\frac{R_{in}}{R_{in}+R_G} = 100mV\cdot\frac{10{,}9}{10{,}9+5} = 69mV$$

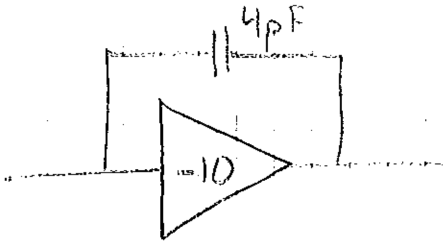
$$V_{out} = A_v\cdot V'\cdot\frac{R_L}{R_{out}+R_L} = 69m\cdot 10\cdot\frac{5}{1+5} = 575mV$$

c)

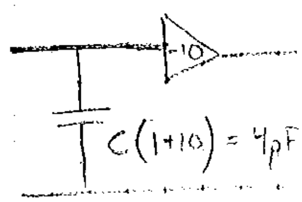
$$f_1 = \frac{1}{2\pi(R_G+R_{in})C_1} \qquad C = \frac{1}{2\pi\cdot 1\cdot 10^3\cdot(5k+10{,}9k)} = 10nF$$

$$f_2 = \frac{1}{2\pi(R_{out}+R_L)C_2} \qquad C = \frac{1}{2\pi\cdot 1\cdot 10^3(1k+5k)} = 26nF$$

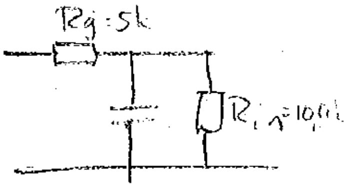
d)



$\Leftrightarrow$



$C(1+10) = 4pF\cdot 11 = 44pF$



$$f_3 = \frac{1}{2\pi(R_1 /\!/ R_2)C} = \frac{1}{2\pi\,\frac{5k\cdot 10{,}9k}{5k+10{,}9k}\cdot 44p} = 1{,}0\,MHz$$