Lösningar
061101

1a) I en linjär regulator är $I_{in} = I_{ut}$ samt $V_{ut} < V_{in}$ vilket ger en effektförlust på $P_{loss} = I(V_{ut} - V_{in})$

b) $R_{in} = \infty$

$R_{out} = 0$

$A_v = \infty$

$I_{in} = 0$

$V_{in\text{-}diff} = 0$

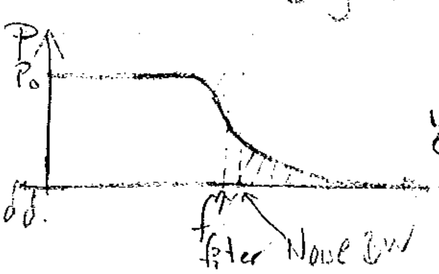
c) 1. CE with bypassed R_E

d) 3. CC

e) 1. CE with bypassed R_E

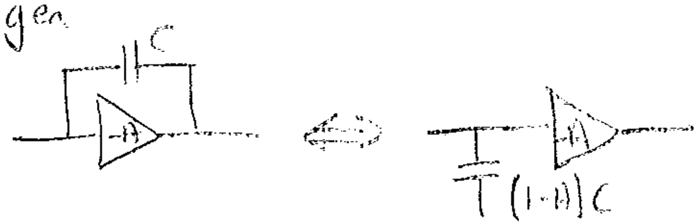
f) 3. CC

g) Brusbandbredd är den ekvivalenta bandbredd bruset verkar om man tänker sig ett oändligt brant filter istället. Alltid lite större än filtrets bandbredd.

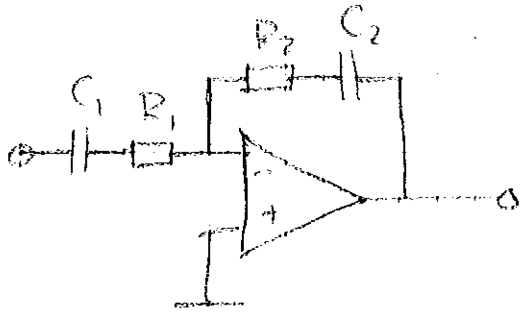


$$\int_0^{BW_N} (P_0 - P) = \int_{BW_N}^{\infty} P$$

h) En kapacitans mellan in och utgång på en inverterande förstärkare upplevs som "förstärkt" på ingången



2 a/



$$H_V = -\frac{Z_2}{Z_1} = -\frac{R_2 + \frac{1}{j\omega C_2}}{R_1 + \frac{1}{j\omega C_1}} = -\frac{j\omega R_2 C_1 + \cancel{j\omega} \frac{C_1}{\cancel{j\omega} C_2}}{1 + j\omega R_1 C_1}$$

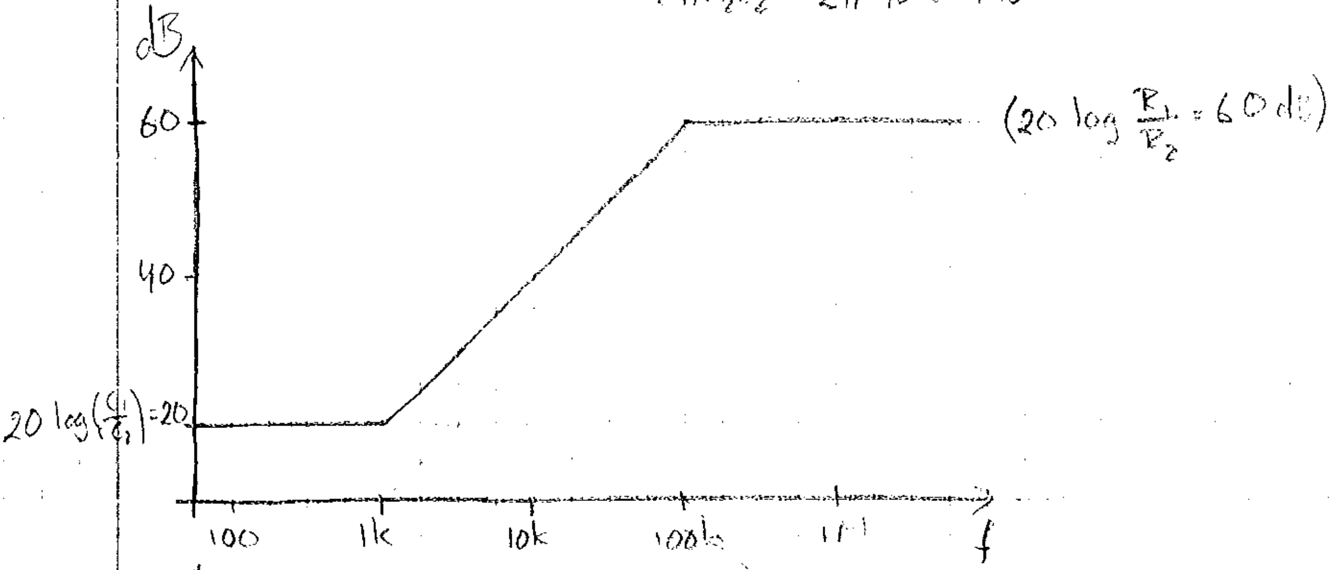
$$= -\frac{C_1}{C_2} \frac{1 + j\omega R_2 \frac{C_2}{\cancel{C_1}} \cdot \cancel{C_1}}{1 + j\omega R_1 C_1} = -\frac{C_1}{C_2} \frac{1 + j\omega R_2 C_2}{1 + j\omega R_1 C_1}$$

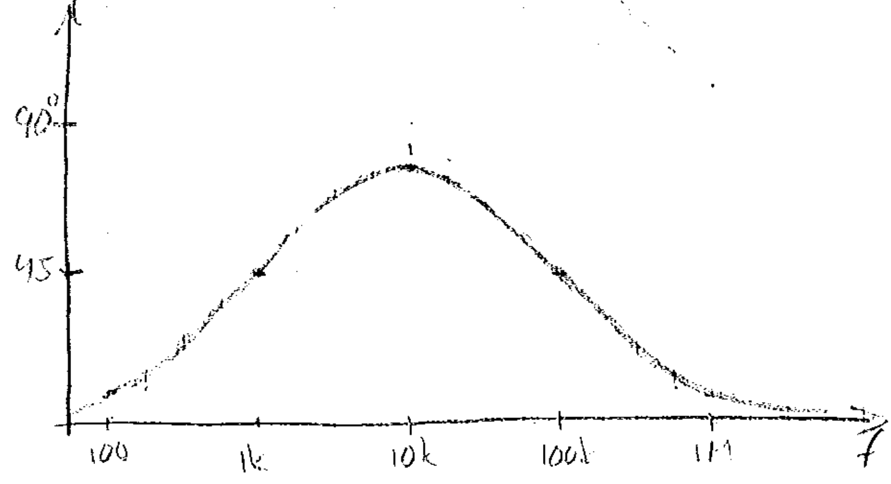
$$= -\frac{C_1}{C_2} \frac{1 + j\frac{\omega}{\omega_2}}{1 + j\frac{\omega}{\omega_1}} = -\frac{C_1}{C_2} \frac{1 + j\frac{f}{f_2}}{1 + j\frac{f}{f_1}}$$

dör $f_1 = \frac{1}{2\pi R_1 C_1} = \frac{1}{2\pi \cdot 40 \cdot 40 \cdot 10^{-9}} = 100 kHz$ (-1 BP)

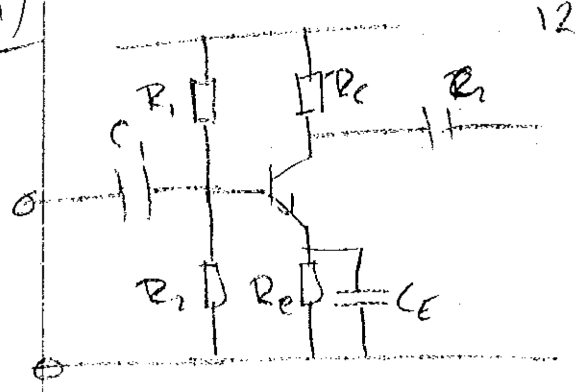
b/

$f_2 = \frac{1}{2\pi R_2 C_2} = \frac{1}{2\pi \cdot 40 \cdot 10^3 \cdot 4 \cdot 10^{-9}} = 1 kHz$ (+1 BP)





3a)

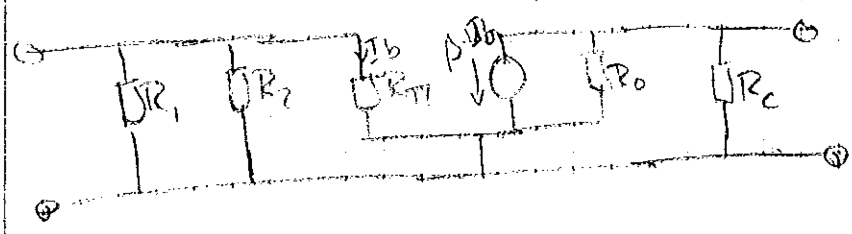


b)

$R_{in} = R_1 // R_2 // R_\pi$

$R_{out} = R_c // R_o$

$A_v = \frac{U_{ut}}{U_{in}} = \frac{-\beta \cdot I_b (R_c // R_o)}{I_b \cdot R_\pi} = -g_m (R_c // R_o)$



c) Set $U_{R_c} = 5V$ $R_{R_e} = 2V$ $R_{CE} = 5V$

$R_{out} = R_c // r_o$ Select $R_c = 500\Omega$

$\Rightarrow I_c = \frac{U_{R_c}}{R_c} = \underline{\underline{10mA}}$

$I_e = I_c \Rightarrow R_e = \frac{U_{Re}}{I_c} = \frac{2}{10m} = \underline{\underline{200\Omega}}$

$I_c = 10mA$, $U_{CE} = 5V$

Datablad $\Rightarrow$ $r_\pi \approx 3{,}5k$ $\beta \approx 600$

$I_B = \frac{I_c}{\beta} = \frac{10m}{600} = 17\mu A$

Select $I_{R_2} = 400\mu A$

$\Rightarrow U_{R_2} = U_{Re} + 0{,}7 \Rightarrow R_2 = \frac{2{,}7}{500\mu} = 6{,}8k\Omega$

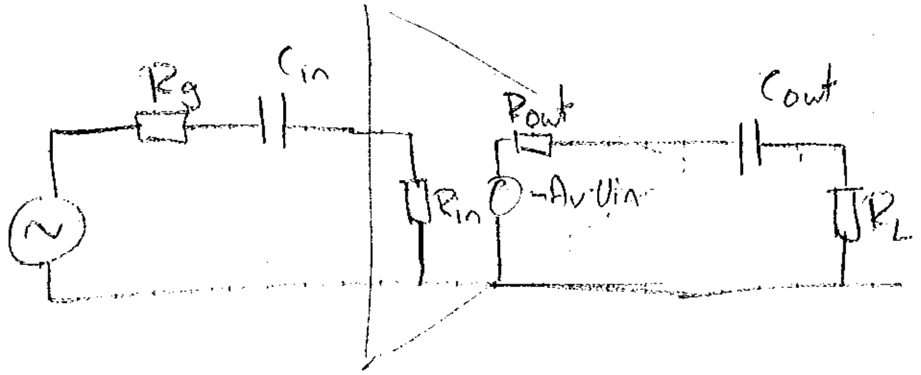
$R_1 = \frac{12 - 2{,}7}{500\mu} = \frac{9{,}3}{500\mu} = 23k\Omega$

$$R_{in} = R_1 // R_2 // R_\pi = \frac{1}{\frac{1}{6{,}8k} + \frac{1}{23k} + \frac{1}{3{,}5k}} = 2{,}1\,k\Omega$$

$$R_{out} = R_c // R_0 = \frac{500 \cdot 10k}{500 + 10k} = 480\,\Omega$$

$$A_v = \frac{\beta_{ac}}{r_\pi}\left(R_c // r_0\right) = \frac{600}{3{,}5k} \cdot 480 = 82 \text{ ggr}$$

4a)

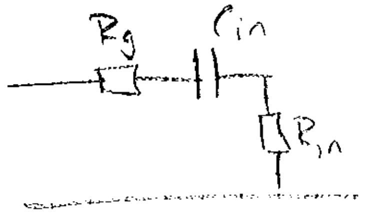


b)

$$U_{out_{peak}} = U_{in} \cdot A_{V_0} \frac{R_{in}}{R_{in}+R_g} \frac{R_L}{R_{out}+R_L} = 1m \cdot 82 \cdot \frac{2,1k}{500+2,1k} \frac{2k}{480 \cdot 2k} =$$

$$= 53\,mV$$

c)



$$f_g = \frac{1}{2\pi(R_g+R_{in})C_{in}} = 20\,Hz$$

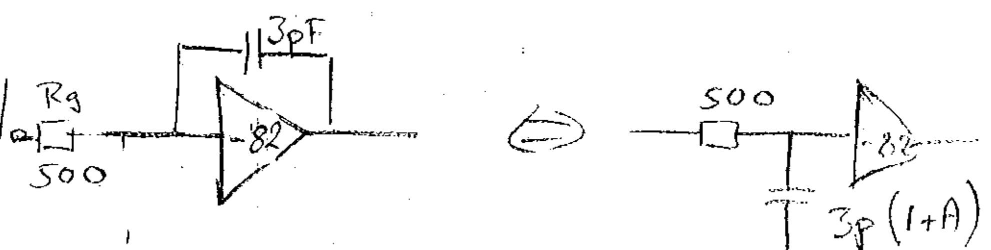
$$C_{in} = \frac{1}{2\pi(500+2,1k)20} = 3,1\mu F$$

pss $$C_{out} = \frac{1}{2\pi(480+2k)20} = 3,2\mu F$$

$$C_E = \frac{1}{2\pi(\underbrace{R_e \| \frac{1}{g_m}}_{})f_c} = \frac{1}{2\pi\, 5,7 \cdot 20} = 1,4\,mF$$

$$\frac{200 \cdot \frac{3,5k}{600}}{200 + \frac{3,5k}{600}} = 5,7\Omega$$

d)

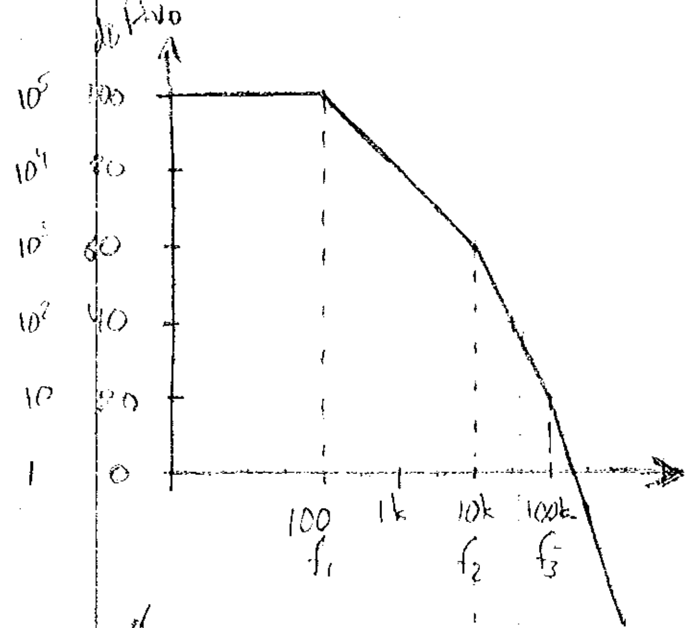


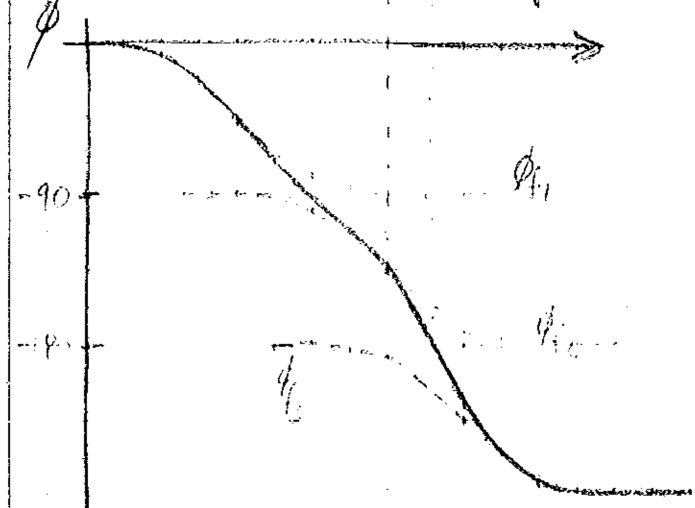
3p·83 = 249pF

$$f_{Miller} = \frac{1}{2\pi R_g C_{Miller}} = \frac{1}{2\pi \cdot 500 \cdot 249 \cdot 10^{-12}}$$

$$= \underline{\underline{1,3\,MHz}}$$

5a)





b) For stable operation without compensation the gain must be reduced so that $\beta A_{v0} = 0$ dB when $\phi = -135^\circ$ that is $\beta = -60$ dB or 10^{-3} which gives $\underline{\beta \cdot A_{v0} = 40 \text{ dB}}$

$\Rightarrow$ phase margin $= -45^\circ$

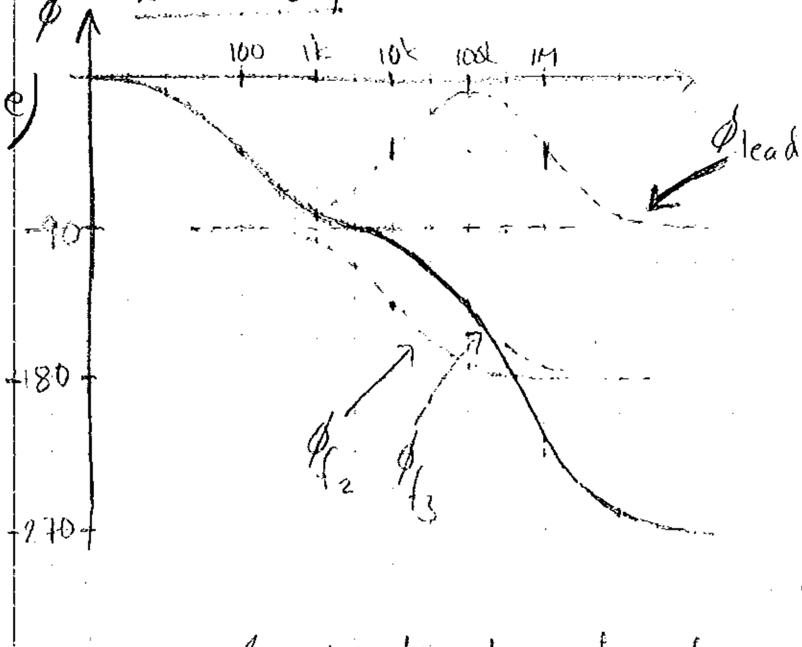
c) Gain

< 38 dB Unstabel

38-60 dB $\phi_m < 45^\circ$

> 60 dB Stabele

e) Lead comp.



d)

$f_{lead1} = f_2 = 10$ k

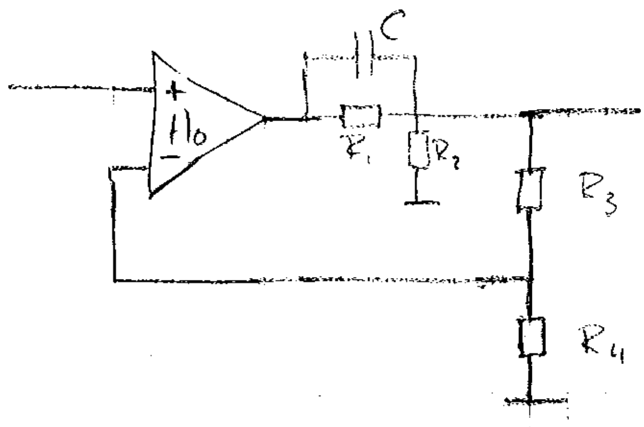
$\beta \cdot A_{v0} = 60$ dB

$\Rightarrow \beta = -40$ dB

Lead filter drops with -20 dB/decade.

For $\beta = -40$ dB two decades can differ between f_{lead1} and f_{lead2}.

$f_{lead2} = 100 \cdot f_{lead1} = 1$ MHz f)



$$f_{1lead} = 10k = \frac{1}{2\pi R_1 C}$$

$$f_{2lead} = 1MHz = \frac{1}{2\pi (R_1 // R_2) C}$$

Låt $R_1 = 10k \Rightarrow C = \frac{1}{2\pi 10k \cdot 10k} = 1{,}6\ nF$

$$\Rightarrow R_1 // R_2 = \frac{1}{2\pi \cdot 1\cdot 10^6 \cdot 16 \cdot 10^{-9}} = 99{,}5\ k$$

$$\Rightarrow R_2 = 100\ \Omega \Rightarrow R_1 // R_2 = 99{,}5\ \Omega$$

20 dB gain $\Leftrightarrow$ 10 times

$$A_v = \frac{R_3}{R_3 + R_4}$$

Låt $R_3 + R_4 = 100k$ (Dvs $\gg R_1$)

$$\Rightarrow \underline{R_3 = 10k\ \Omega} \text{ och } \underline{R_4 = 90k\ \Omega}$$

ger $A_v = 10 = 20 dB$