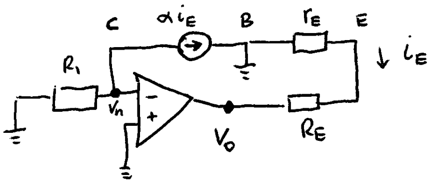
(a) $I_E = \frac{V_i}{R_1} = \frac{8V}{1k\Omega} = 8\ mA$ $(V_i = V_{max}\ !)$

$r_E = \frac{V_T}{I_E} = 26mV/8mA = 3.25\ \Omega$

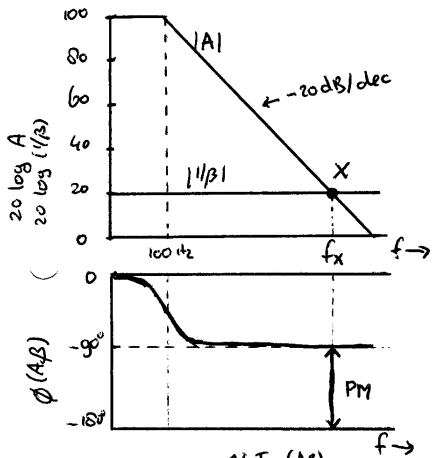
determine β : $\beta = \frac{V_n}{V_o}$



V_n : $\sum I = 0$

$V_n \cdot \frac{1}{R_1} + \alpha i_E = 0$, $i_E = \frac{-V_o}{R_E'}$, $R_E' = R_E + r_E$

$\Rightarrow \frac{V_n}{V_o} = \beta = \frac{R_1}{R_E'} = \frac{1k\Omega}{10k\Omega + 3.25\Omega} = \frac{1}{10}$, $1/\beta = 10$



A: 1 pólo , $f_p = 100$ Hz

$A = \frac{A_0}{1 + if/f_p}$

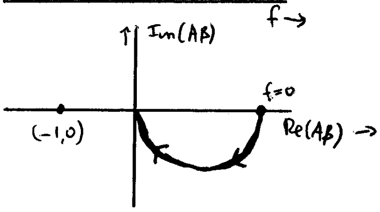
β : 0 pólos , $\beta = 0.1$

X: $|A| = |1/\beta|$ $|A\beta| = 1$

$|A| = \frac{A_0}{1 + f_x/f_p}$, $(f_x >> f_c)$

$|A| \sim A_0 f_p/f_x$

$|A\beta| = 1 \Rightarrow A_0 f_p/f_x = 10 \Rightarrow f_x = 1\ MHz$



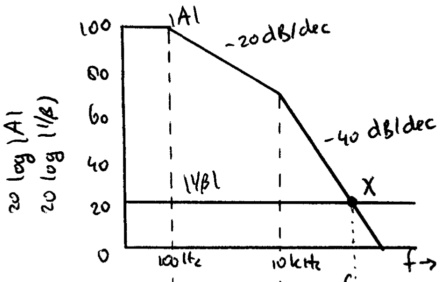
$\phi(f_x) = -\tan^{-1}(f_x/f_p) = -89.99°$

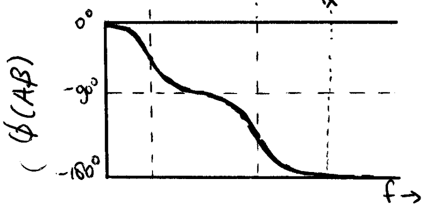
margem de fase :

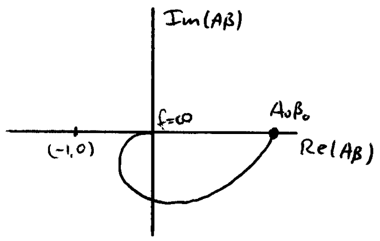
$PM = 180° - 89.99° = 90.01°$

$PM > 45° \Rightarrow$ estável

(b)







$\beta = 0.10$, $1/\beta = 10$, $20 \log |1/\beta| = 20$ dB

$$A = \frac{A_0}{(1 + if/f_{p1})(1 + if/f_{p2})}$$

X: $|A\beta| = 1$

da figura : $\phi(A\beta) \approx -180°$

$\Rightarrow$ instável

$$\frac{A}{1 + A\beta} \sim \frac{A_x}{1 + (-1)} = \infty$$

determine f_x :

$$|A(f_x)| = \frac{A_0}{(1 + f_x/f_{p1})(1 + f_x/f_{p2})}$$

$f_x \gg f_{p2} \gg f_{p1}$

$$|A(f_x)| = \frac{A_0}{(f_x/f_{p1})(f_x/f_{p2})}$$

$$= \frac{A_0 f_{p1} f_{p2}}{f^2}$$

$|A\beta| = 1 \Rightarrow f^2 = A_0 f_{p1} f_{p2} \beta$

$= 10^5 \cdot 100 \cdot 10^4 \cdot 0.1$

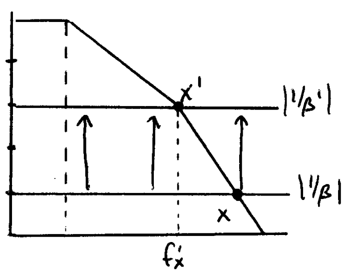
$f = 100$ kHz

$\phi(100 \text{ kHz}) = -\tan^{-1}(f/f_{p1}) - \tan^{-1}(f/f_{p2}) = -89.94° - 84.29$

$= -174.23°$

PM $= 180 - 174.23° = 5.77°$ ($< 45° \Rightarrow$ não é estável)

(c)



$\phi(x') = -135°$ (PM = 45°)

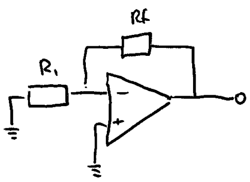
$f_{x'} = 10$ kHz ($= f_{p2}$)

$$A(x') = \frac{A_0 f_{p1} f_{p2}}{f^2} = \frac{10^5 \cdot 100 \cdot 10^4}{10^4 \cdot 10^4} = 10^3$$

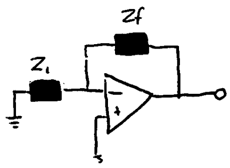
$\Rightarrow \beta' = 10^{-3}$ ($A\beta' = 1$)

$$\Rightarrow \frac{R_1}{R_E + r_E} = 10^{-3} \Rightarrow R_E = 1\ M\Omega$$

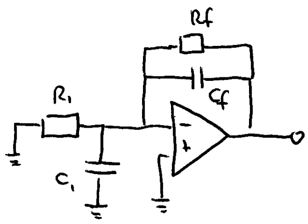
intermezzo. general description



$$\beta = \frac{R_1}{R_1 + R_f}$$



$$\beta = \frac{1/z_1}{1/z_1 + 1/z_f}$$



$$z_1 = 1/R_1 + sC_1$$

$$z_f = 1/R_f + sC_f$$

$$\beta = \frac{1/z_1}{1/z_1 + 1/z_f} = \frac{\frac{1}{1/R_1 + sC_1}}{\frac{1}{1/R_1 + sC_1} + \frac{1}{1/R_f + sC_f}} = \frac{1/R_f + sC_f}{1/R_f + sC_f + 1/R_1 + sC_1}$$

$$= \frac{R_1}{R_1 + R_f} \cdot \frac{1 + sR_fC_f}{1 + s\left(\frac{R_f R_1}{R_1 + R_f}\right)(C_1 + C_f)}$$

$\beta_0 = \frac{1}{11}$

pole at

$$f_p = \frac{1}{2\pi (R_1 /\!/ R_f) \cdot (C_1 + C_f)}$$

$= 173.3$ kHz

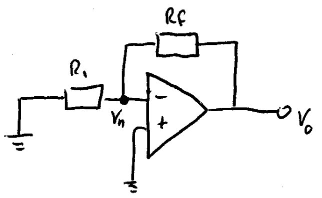
zero at

$$f_0 = \frac{1}{2\pi R_f C_f}$$

$R_1 = 1\,k\Omega$
$R_f = R_E + r_E = 10\,k\Omega$
$C_1 = C_i = 10\,pF$
$C_f = C_c = 1\,nF$

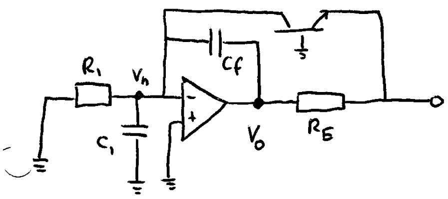
} example

end of intermezzo

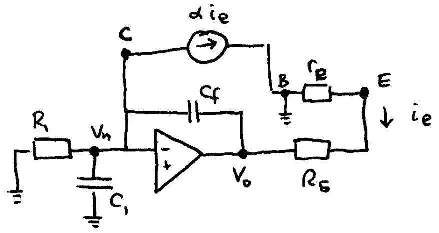


$$\beta = \frac{V_n}{V_o} = \frac{R_1}{R_1 + R_f}$$

small signal analysis of log. amp.



$\Longrightarrow$



$$i_e = \frac{V_o}{R_E + r_E} = -\frac{V_o}{R_f} \qquad R_f = R_E + r_E$$

in V_n : $\sum I = 0$

$$V_n \left(\frac{1}{R_1} + sC_1\right) + \alpha\, i_e + (V_n - V_o) \cdot sC_f = 0$$

$$V_n \left(\frac{1}{R_1} + sC_1\right) - \alpha \frac{V_o}{R_f} + (V_n - V_o)\, sC_f = 0 \qquad R_f = R_E + r_E$$

$$\beta = \frac{V_n}{V_o} = \frac{\frac{\alpha}{R_f} + sC_f}{1/R_1 + sC_1 + sC_f} \qquad (\alpha = 1) \Rightarrow \beta = \frac{R_1}{R_f}\,\frac{1 + sR_fC_f}{1 + sR_1(C_1 + C_f)}$$

$\beta_o = \frac{1}{10}$

pole at $f_p = \frac{1}{2\pi R_1 (C_1 + C_f)}$ $\Downarrow$ 158 kHz

zero at $f_o = \frac{1}{2\pi R_f C_f}$ $\Downarrow$ 15.9 kHz

$R_1 = 1\,k\Omega$

$R_f = 10\,k\Omega$

$C_1 = 10\,pF$

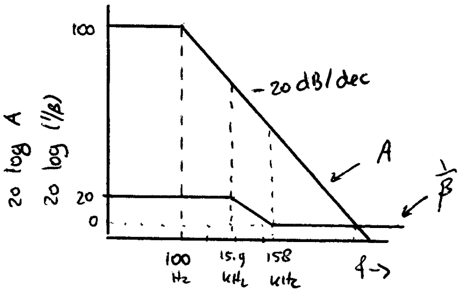
$C_f = 1\,nF$

F.P. 3 E-III

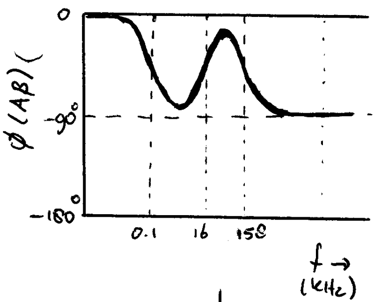
A: pole at 100 Hz $\qquad A_0 = 10^5$

β: pole at 158 kHz $\qquad \beta_0 = 0.1$

zero at 15.9 kHz

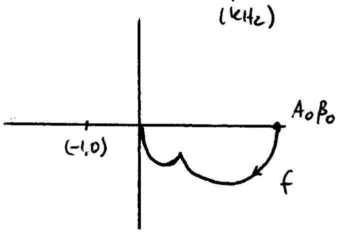


$$\beta(f=\infty)_{C_1=0} = \frac{R_1}{R_1+R_f} \cdot \frac{R_f}{R_f R_1} \cdot \frac{R_f+R_1}{} = 1$$



∀f: φ(Aβ) > -90°

stable!



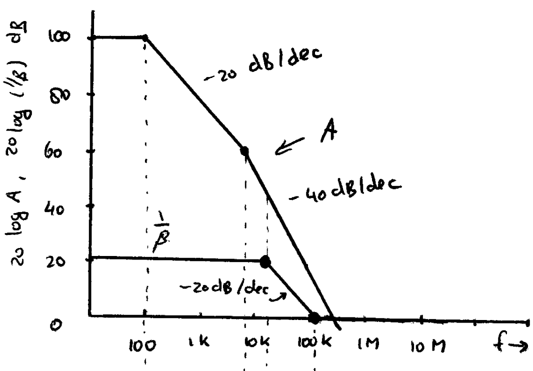
ampop de (b):

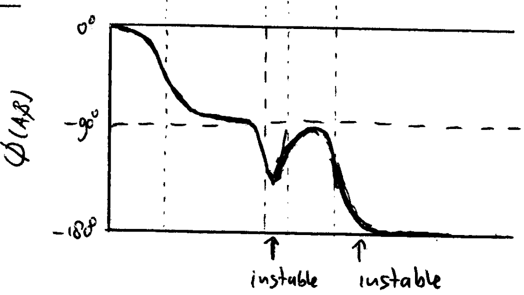
A: pole at 100 Hz

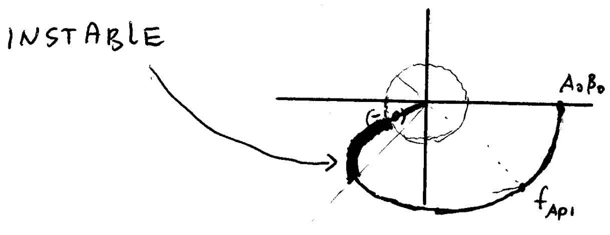
pole at 10 kHz

β: pole at 158 kHz

zero at 15.9 kHz







end