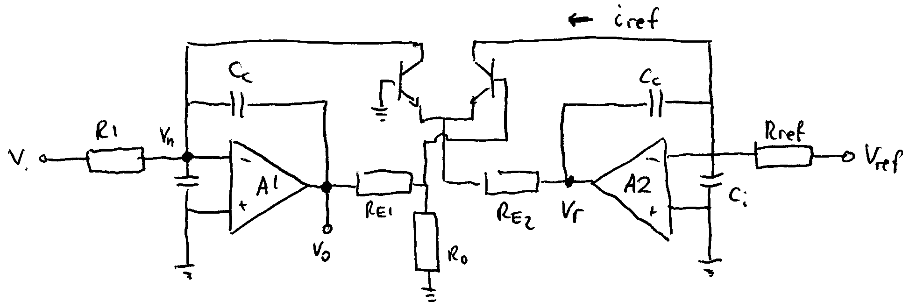


Determine the feedback ratio $\beta = \frac{V_n}{V_o}$

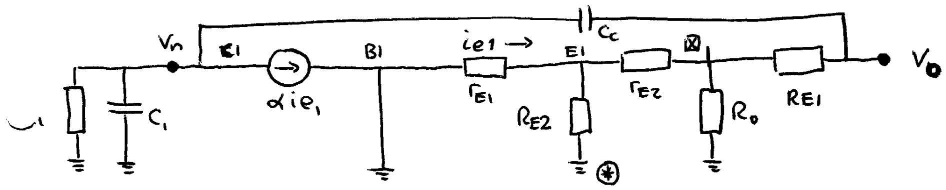
1) The right amplifier, A2 : constant mode

i_{ref} = constant = $\frac{V_{ref}}{R_{ref}}$

V_r = constant

2) small signal analysis

- voltage source ⇒ ground ⊛
- current source ⇒ open circuit ⊠

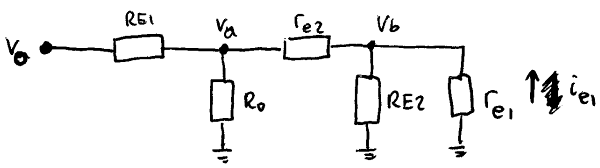


determine i_{e_1} :

$$i_{e_1} = - V_n \cdot R_{eq}$$

$$i_{ref} = \frac{V_{ref}}{R_{ref}} = \frac{10\ V}{1\ k\Omega} = 10\ mA \ , \quad r_{E2} = \frac{V_T}{i_{ref}} = \frac{26\ mV}{10\ mA} = 2.6\ \Omega$$

$$\max i_1 = \frac{V_{max}}{R_1} = \frac{10\ V}{1\ k\Omega} = 10\ mA \ , \quad r_{E1} = 2.6\ \Omega$$



RE1 = 10 k
RE2 = 10k
Ro = 10k
$r_{e1} = r_{e2} = 2.6\ \Omega$

$$V_a = V_o \cdot \frac{R_x}{R_x + RE1}, \quad R_x = Ro \,//\, (r_{e2} + RE2 \,//\, r_{e1})$$

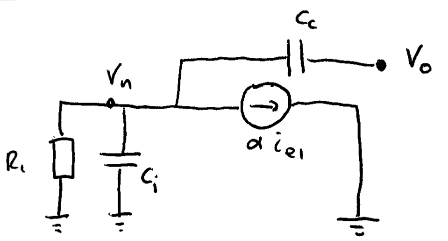
$$R_x = 10\text{ k} \,//\, (2.6\ \Omega + 10\text{ k} \,//\, 2.6\ \Omega)$$
$$= 10\text{ k} \,//\, 5.2\ \Omega$$
$$= 5.2\ \Omega$$

$$V_a = V_o \cdot \frac{5.2}{5.2 + 10\text{ k}} = 5.2\ 10^{-4}\ V_n$$

$$V_b = V_a \cdot \frac{R_y}{R_y + r_{e2}}, \quad R_y = RE2 \,//\, r_{e1} \sim r_{e1} = 2.6\ \Omega$$

$$V_b = V_a \cdot \frac{2.6}{2.6 + 2.6} = 0.5\ V_a = 0.5 \times 5.2\ 10^{-4}\ V_o$$
$$= 2.6\ 10^{-4}\ V_o$$

$$\boxed{V_b \approx \frac{r_{e1}}{R_{E1}} \cdot V_n} \qquad i_{e1} = -\frac{V_b}{r_{e1}} = -\frac{V_o}{R_{E1}}$$



In V_n : $\sum I = 0$

$\alpha = 1$

$$V_n \left(\frac{1}{R_1} + sC_1\right) + (V_n - V_o)\, sC_c - V_o \frac{1}{R_{E1}} = 0$$

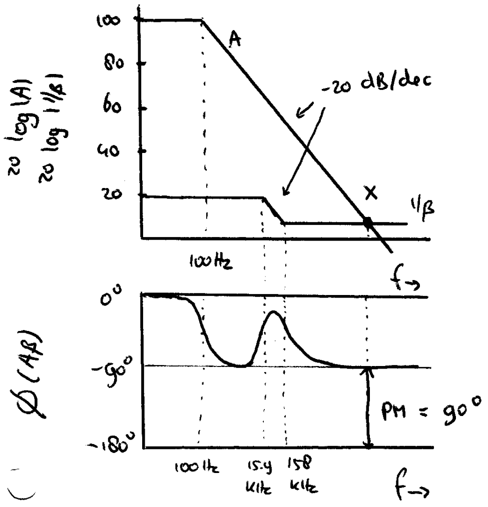
$$\beta = \frac{V_n}{V_o} = \frac{1/R_{E1} + sC_c}{1/R_1 + sC_1 + sC_c} = \frac{R_1}{R_{E1}} \cdot \frac{1 + sR_{E1}C_c}{1 + sR_1(C_1 + C_c)}$$

$R_1 = 1\text{k}\Omega$
$C_1 = 10\text{ pF}$
$C_c = 1\text{ nF}$
$R_{E1} = 10\text{ k}\Omega$

$\beta_0 = 0.1$

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

zero at
$$f_0 = \frac{1}{2\pi R_{E1} C_c}$$
15.9 kHz



$$\beta = \frac{R_1}{R_{E1}} \cdot \frac{1 + sR_{E1}C_c}{1 + sR_1(C_1 + C_c)}$$

$$\beta(f{=}0) = \frac{R_1}{R_{E1}} = 0.1$$

$$\beta(f{=}\infty) = \frac{\cancel{R_1}}{\cancel{R_{E1}}} \cdot \frac{\cancel{R_{E1}}\,C_c}{\cancel{R_1}(C_1+C_c)} \approx 1$$

f_x :

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

em X : $|A| = |\beta(f{=}\infty)|$

$$A_0 \frac{f_p}{f_x} = \beta_\infty = 1 \Rightarrow f_x = A_0 f_p$$

$$= 10^7 \text{ Hz} = 10 \text{ MHz}$$

In reality, this circuit is probably not stable due to the fact that the OpAmp will have more poles before 10 MHz.

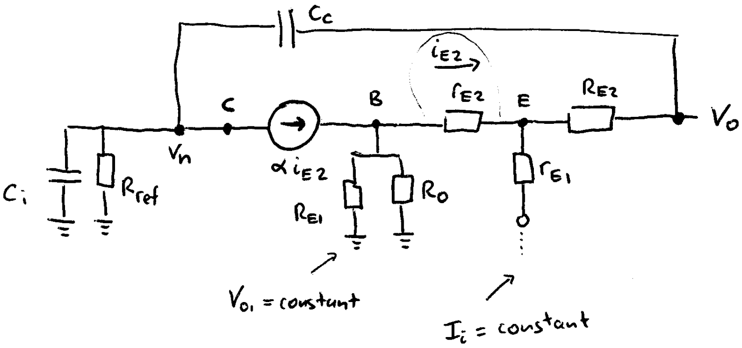
---

stability of right part of circuit

left amplifier A1 constant mode

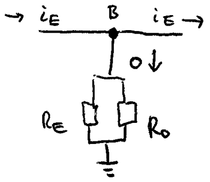
i_1 = constant (= V_{max}/R_1)

V_0 = constant



$\alpha = 1$

Kirchov in B $(\alpha = 1)$



No current through $R_E // R_o \Rightarrow$

$V_B = 0\ V$

$$\overline{i_{E2}} = \frac{V_B - V_o}{R_{E2} + r_{E2}} = -\frac{V_o}{R_{E2} + r_{E2}} = -\frac{V_o}{R'_{E2}}$$

In V_n : $\sum I = 0$

$$V_n \left(\frac{1}{R_{ref}} + sC_i \right) + \alpha\, i_{E2} + sC_c (V_n - V_o) = 0$$

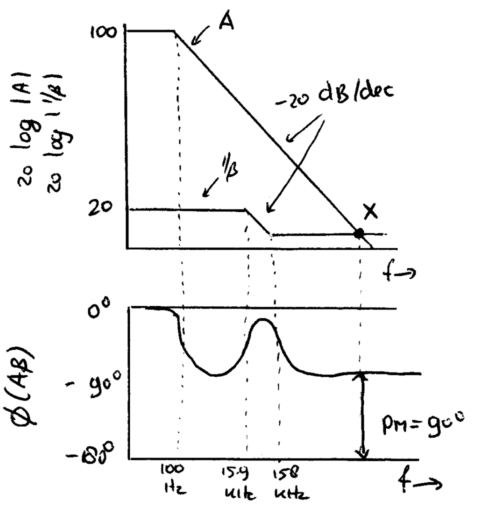
$$V_n \left(\frac{1}{R_{ref}} + sC_i \right) - V_o \left(\frac{1}{R'_E} \right) + sC_c (V_n - V_o) = 0$$

$$\beta = \frac{V_n}{V_o} = \frac{1/R'_E + sC_c}{1/R_{ref} + sC_i + sC_c} = \frac{R_{ref}}{R'_E} \cdot \frac{(1 + sR'_E C_c)}{(1 + sR_{ref}(C_i + C_c))}$$

$\beta_o = 0.1$

pólo at $f_p = \dfrac{1}{2\pi R_{ref}(C_i + C_c)} = 158\ kHz$

zero at $f_o = \dfrac{1}{2\pi R'_E C_c} = 15.9\ kHz$



equal to (a)