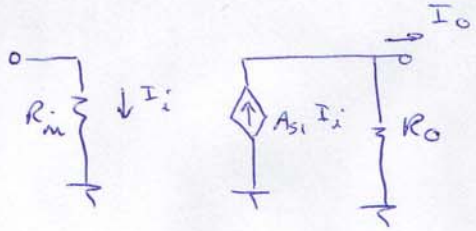
Quiz 1 Set A 8

Question 1)

a)

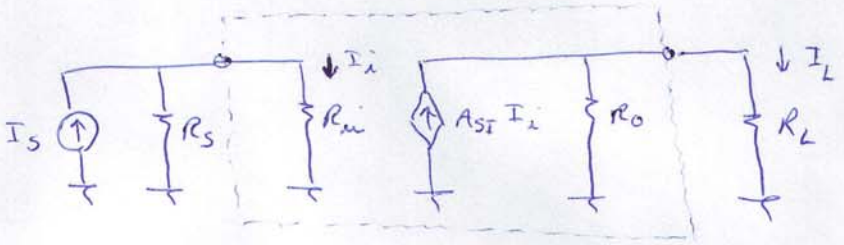


R_{in} : input resistance

R_o : output resistance

A_{SI} : short-circuit current gain

b)



$$I_i = I_S \times \frac{R_S}{R_S + R_{in}}$$

$$\Rightarrow \frac{I_i}{I_S} = \frac{R_S}{R_S + R_{in}} \quad (I)$$

$$I_L = A_{SI} I_i \times \frac{R_o}{R_o + R_L}$$

$$\Rightarrow \frac{I_L}{I_i} = A_{SI} \frac{R_o}{R_o + R_L} \quad (II)$$

$$(I), (II) \Rightarrow \frac{I_L}{I_S} = \frac{I_L}{I_i} \times \frac{I_i}{I_S} \Rightarrow \frac{I_L}{I_S} = \frac{R_S}{R_S + R_{in}} \times A_{SI} \times \frac{R_o}{R_o + R_L}$$

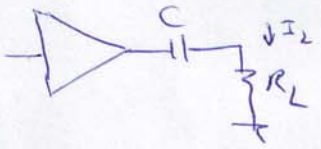
c) $R_S = 1\ M\Omega$, $R_{in} = 100\ \Omega$, $R_o = 1\ M\Omega$, $R_L = 100\ \Omega$, $A_{SI} = 100\ A/A$

$$\frac{I_L}{I_S} = \frac{R_S}{R_S + R_i} \times A_{SI} \times \frac{R_o}{R_o + R_L} = \frac{1000^{K}}{1000^{K} + 0.1} \times 100 \times \frac{1000^{K}}{1000^{K} + 1}$$

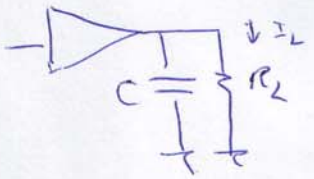
$$\frac{I_L}{I_S} = 99.98 \ {}^{A}/_{A} \simeq 100 \ {}^{A}/_{A}$$

d) There are two ways to place a capacitor at the output of the current amplifier :

① in series with R_L :



② in parallel with R_L :

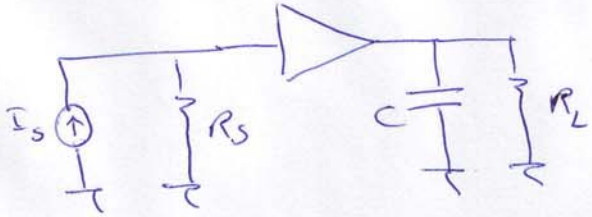


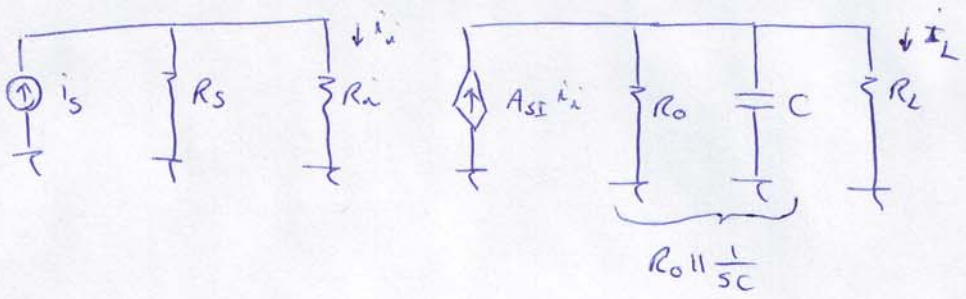
at dc ($f = 0$ Hz) the capacitor is open-circuit ($X_C = \frac{1}{j\omega C}$) and at very high frequencies ($f \to \infty$) the capacitor is short-circuit

$\Rightarrow$ design ① is high-pass ($I_L \simeq 0$ at low frequencies)

design ② is low-pass ($I_L \simeq 0$ at hig frequencies)

design ② :





$$\left.\begin{aligned} \frac{i_i}{i_s} &= \frac{\frac{1}{R_{in}}}{\frac{1}{R_{in}}+\frac{1}{R_s}} = \frac{R_s}{R_s+R_{in}} \\ \frac{i_L}{i_i} &= A_{SI} \times \frac{\frac{1}{R_L}}{\frac{1}{R_L}+\frac{1}{R_o}+sC} \end{aligned}\right\} \Rightarrow \frac{i_L}{i_s} = \frac{i_i}{i_s} \times \frac{i_L}{i_i}$$

$$= \frac{R_s}{R_s+R_{in}} \times A_{SI} \times \frac{R_o}{R_L+R_o+sCR_LR_o}$$

$$\Rightarrow \frac{i_L}{i_s} = \frac{R_s}{R_s+R_{in}} A_{SI} \times \frac{R_o}{R_L+R_o} \times \frac{1}{1+sC\frac{R_oR_L}{R_o+R_L}}$$

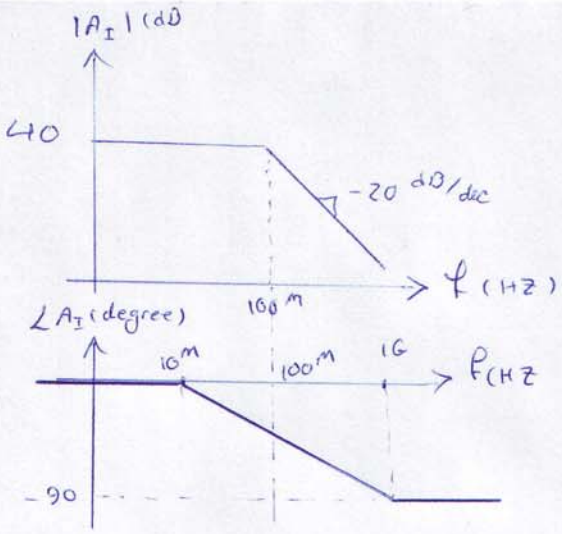
which is similar to the standard LP transfer function: $TF = K\frac{1}{1+\frac{s}{\omega_o}}$

$$\omega_o = \frac{1}{C\frac{R_oR_L}{R_o+R_L}} = \frac{1}{C(R_o \| R_L)}$$

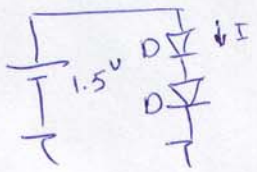
$$\Rightarrow f_o = \frac{1}{2\pi C(R_o \| R_L)} = 100\ MHz$$

$$\Rightarrow C = \frac{1}{2\pi \times 10^8 \times (100 \| 10^6)} \simeq 15.9 \times 10^{-12}\ F = 15.9\ pF$$

f) $$\left.\frac{i_L}{i_s}\right|_{dc} = \frac{R_s}{R_s+R_{in}} \times A_{SI} \times \frac{R_o}{R_o+R_L} = 100\ A/A = 40\ dA$$


$|A_I|$ (dB)
40
-20 dB/dec
f (Hz)
100 m
$\angle A_I$ (degree)
10m
100m
1G
f (Hz)
-90

Question 2)



identical diodes $\Rightarrow V_{D_1} = V_{D_2}$

$V_{D_1} + V_{D_2} = 1.5\,V \Rightarrow$

$V_{D_1} = V_{D_2} = \frac{1.5\,V}{2} = 0.75\,V$

$I = I_S e^{\frac{V_D}{nV_T}} = 10^{-9} e^{\frac{0.75}{2 \cdot 0.025}} = 3.27\,mA$