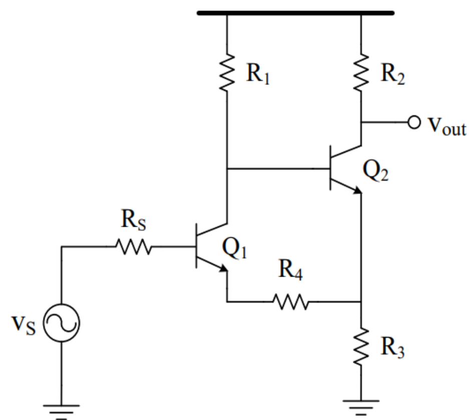
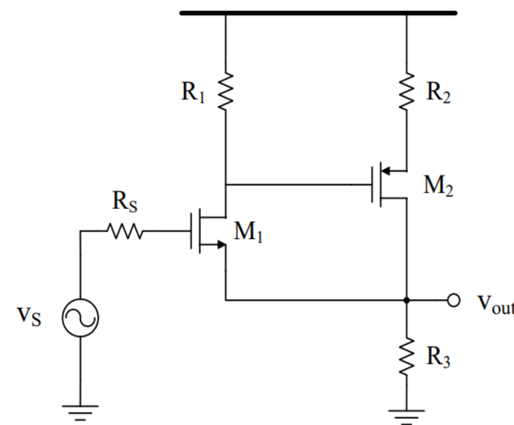
1- In the following circuits, specify the feedback network, main amplifier section and the type of the feedback.

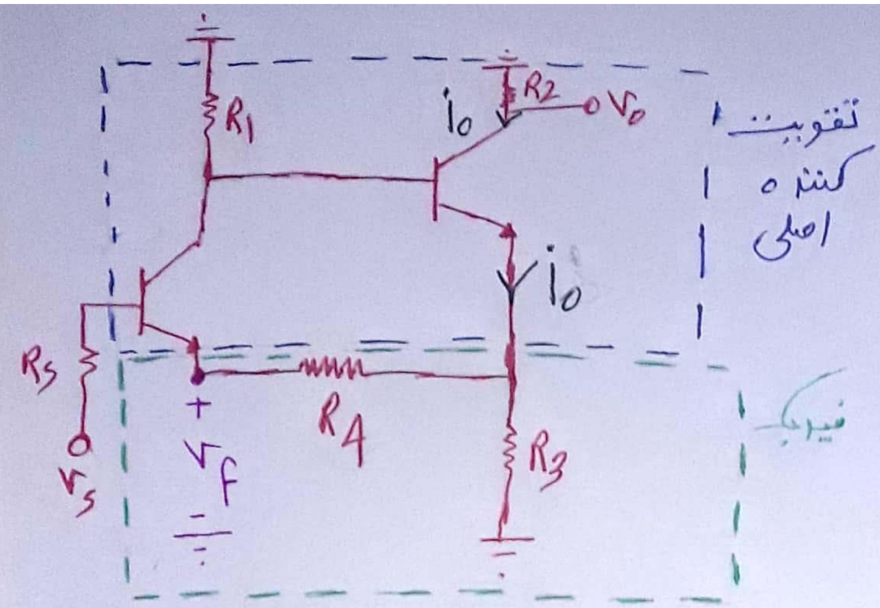


(a)



(b)

1-a

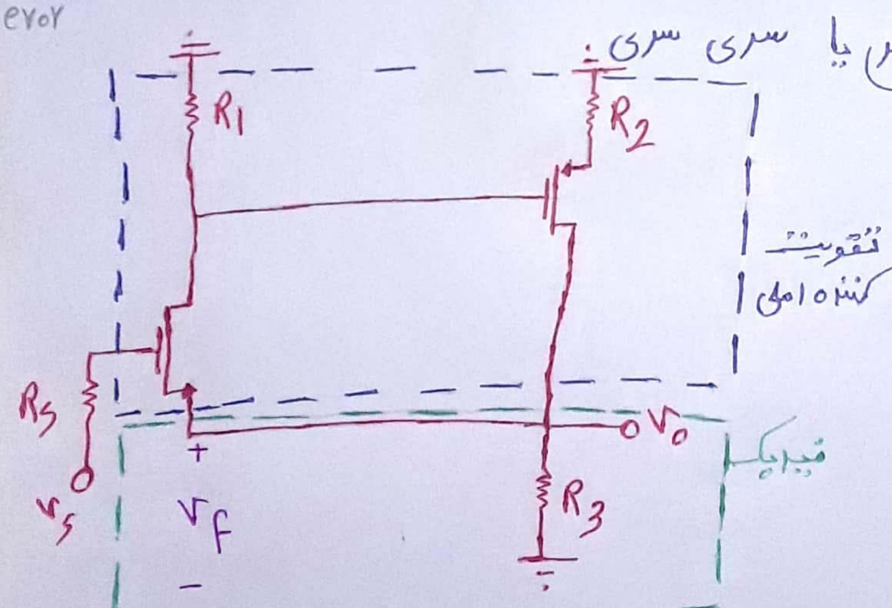


$V_{BE} = V_s - f$

error

فیدبک جریان سری یا سری سری

1b



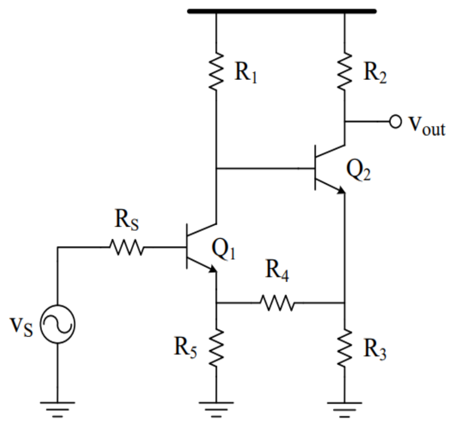
$V_s - V_f = V_{GS}$

error

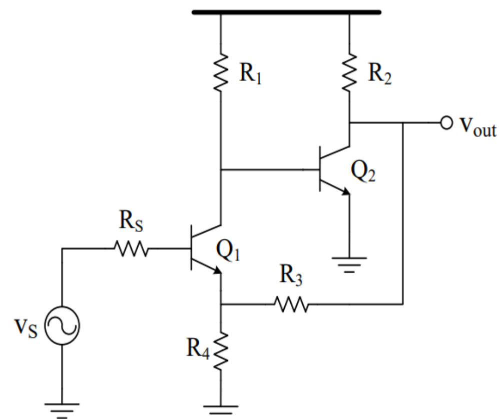
فیدبک ولتاژ سری یا سری موازی

2- Determine the sign of the feedback in the following circuits.

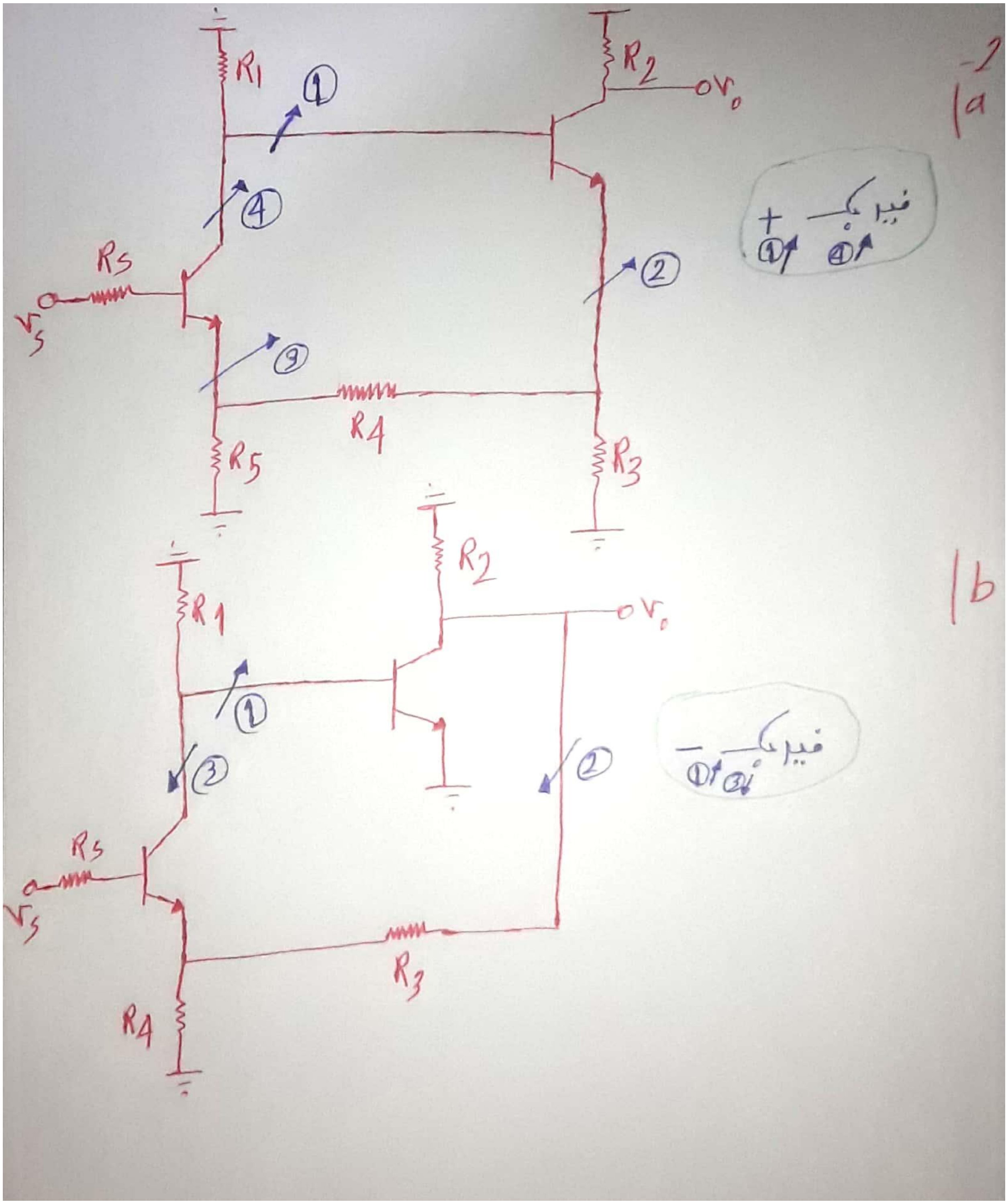
.



(a)

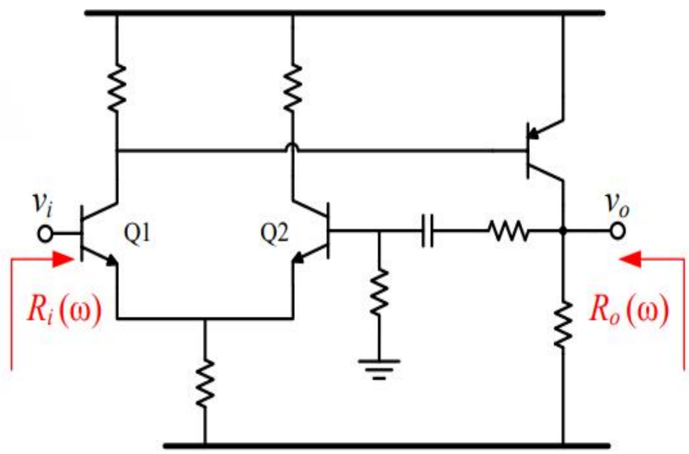


(b)



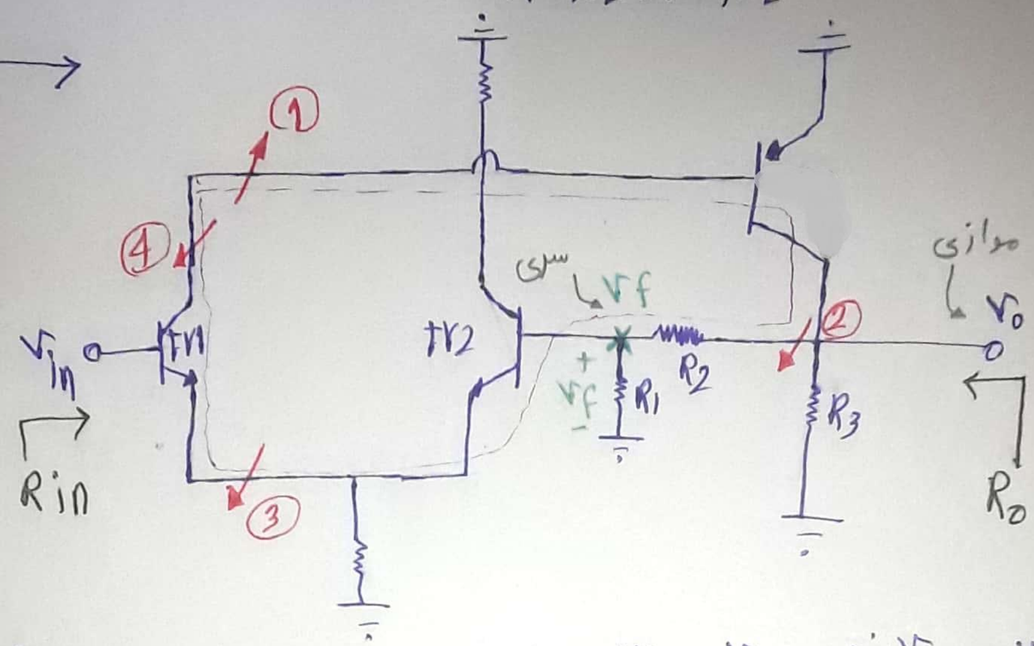
1a
R1
R2
vo
Rs
vs
R4
R5
R3
+
فیدبک
1b
R1
R2
vo
Rs
vs
R3
R4
-
فیدبک

3- In the circuit shown below, $R_i(\omega)$ and $R_o(\omega)$ are the input resistance and output resistance in terms of ω. How do $R_i(\omega)$ and $R_o(\omega)$ change as the frequency varies from 0 to infinity. (Hint: Capacitor is modeled as an open-circuit in ω=0 and as a short-circuit as the frequency goes to infinity)



$\downarrow \omega \rightarrow$ فیدبک وجود ندارد $\rightarrow (R_o)_{oL}$ و $(R_{in})_{oL}$

$\uparrow \omega \rightarrow$



$\left.\begin{array}{l} ① \uparrow \\ ④ \downarrow \end{array}\right\} \rightarrow$ فیدبک -

$$KVL: -v_{in}+v_{be1}-v_{be2}+v_f=0$$

$$\underbrace{v_{be1}-v_{be2}}_{eror} = v_{in}-v_f$$

فیدبک ولتاژ سری یا سری موازی ←

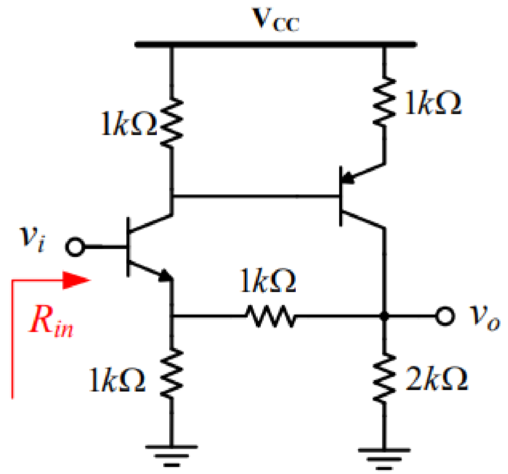
$$(R_o)_{CL} = \frac{(R_o)_{oL}}{1+T}$$

$T = A\beta \rightarrow$ بهره حلقه

$$(R_{in})_{CL} = (R_{in})_{oL} \times (1+T)$$

پس با افزایش ω ها مقاومت ورودی افزایش و مقاومت خروجی کاهش می یابد.

4- Calculate the input resistance of the following figure.



$$\begin{cases} r_\pi = 1k\Omega \\ \beta = 50 \end{cases}$$

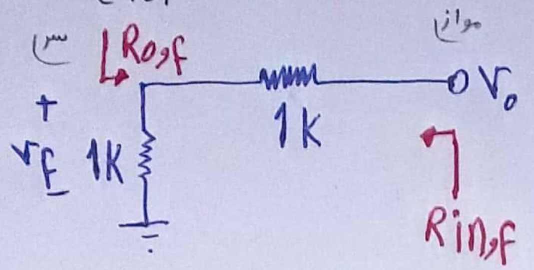
A-

? = Rin

فیدبک ولتاژ سری یا سری موازی

$v_f = v_{in} - v_{BE}$

error

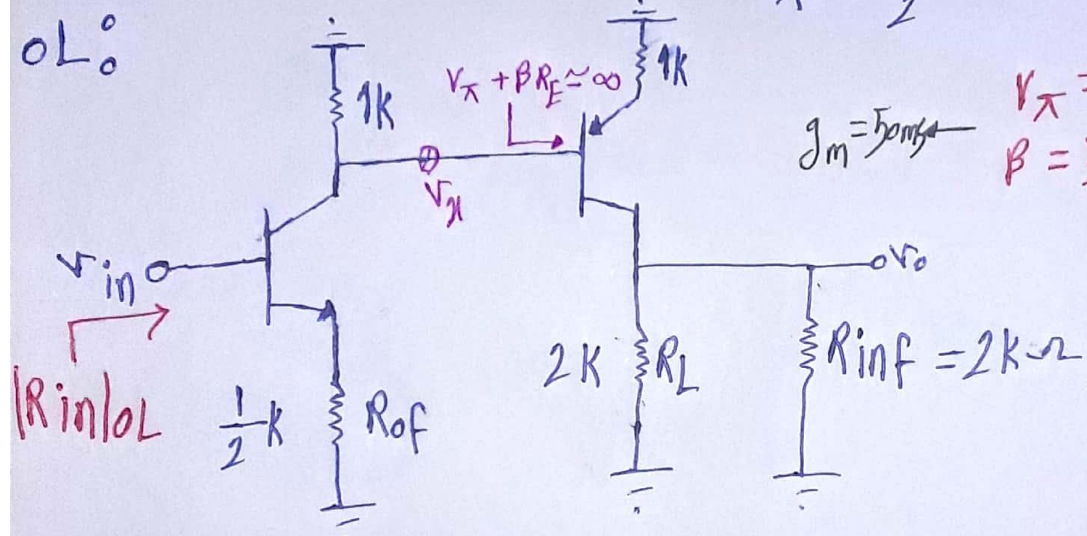


$$\beta = \frac{v_f}{v_o} = \frac{1}{2}$$

$$R_{in,f} = 2k\Omega$$

$$R_{o,f} = \frac{1}{2} k\Omega$$

OL:



$r_\pi = 1k\Omega$

$\beta = 50$

$$(R_{in})_{OL} = r_\pi + (\beta + 1)R_E = 26.5k\Omega$$

$$A_{OL} = \frac{v_o}{v_{in}} = \frac{v_o}{v_x} \times \frac{v_x}{v_{in}}$$

$$\frac{v_o}{v_x} = \frac{-R_C}{R_E + \frac{1}{g_m}} = \frac{-1}{1 + \frac{1}{50}} \simeq -1$$

$$A_{OL} = +2$$

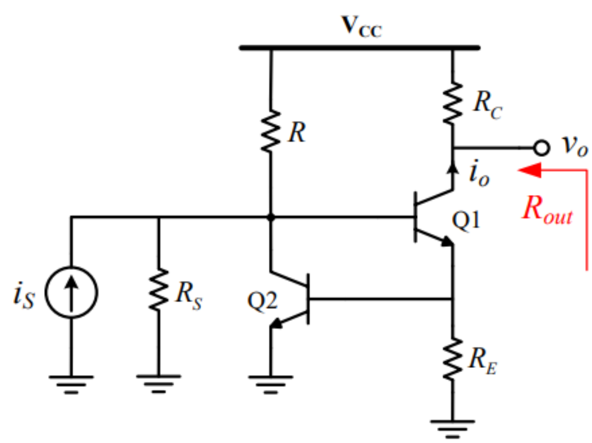
$$\frac{v_x}{v_{in}} = \frac{-R_C}{R_E + \frac{1}{g_m}} = \frac{-(1 \| 51)}{\frac{1}{2} + \frac{1}{50}} \simeq -2$$

$$\left.\begin{aligned} A_{OL} &= +2 \\ \beta &= \frac{1}{2} \end{aligned}\right\} \longrightarrow T = \beta A = +1$$

$T \rightarrow$ بهره حلقه

$$R_{in,CL} = R_{in,OL}(1+T) = 26.5(2) = 53\,k\Omega$$

5- In the following circuit, specify the type of the feedback configuration. In addition, calculate the current gain ($\frac{i_o}{i_S}$) and the output resistance.



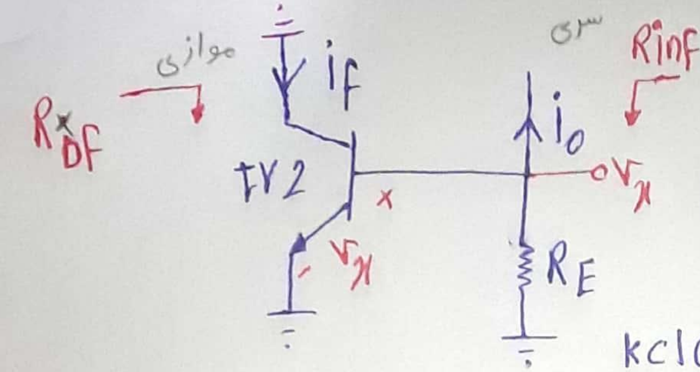
5 | نوع فیدبک؟

$R_{out} = ?$ $\quad \frac{i_o}{i_s} = ?$

error

$i_s - i_f = i_B$

فیدبک جریان موازی یا موازی سری



$$\beta = \frac{i_f}{i_o}$$

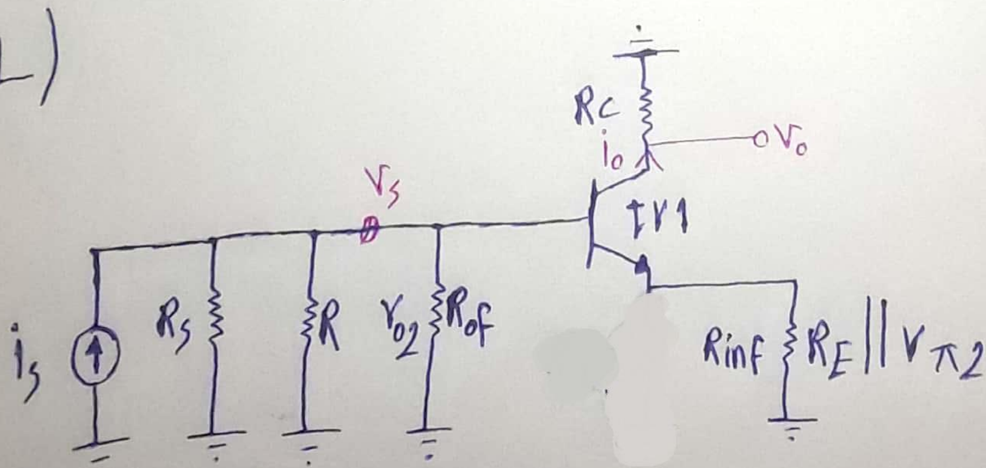
$$v_x = \frac{1}{g_{m2}} i_f$$

$$KCL@v_x: \frac{v_x}{R_E} + \frac{i_f}{\beta_2} = -i_o$$

$$\frac{1}{R_E g_{m2}} i_f + \frac{i_f}{\beta_2} = -i_o \longrightarrow \frac{i_f}{i_o} = \frac{-\beta_2 R_E g_{m2}}{\beta_2 + R_E g_{m2}} = \beta$$

$$R_{in,f} = R_E \| r_{\pi 2} \qquad R_{of} = r_{o2}$$

OL)



$$A_{OL} = \frac{i_o}{i_s} = \frac{i_o}{v_o} \times \frac{v_o}{v_s} \times \frac{v_s}{i_s}$$

$$\frac{i_o}{v_o} = \frac{1}{R_C} \qquad \frac{v_o}{v_s} = \frac{-R_C}{R_E \| r_{\pi 2} + \frac{1}{g_{m1}}}$$

$$\frac{v_s}{i_s} = R_s \| R \| r_{o2} \| (r_{\pi 1} + (\beta_1 + 1)[R_E \| r_{\pi 2}])$$

$$\frac{v_s}{i_s} \simeq R \| R_s$$

$$A_{OL} = \frac{-R \| R_s}{R_E \| r_{\pi 2} + \frac{1}{g_{m1}}} \simeq \frac{-R \| R_s}{R_E \| r_{\pi 2}}$$

$$(R_o)_{OL} = r_{o1}(1 + g_{m1}(R_E \| r_{\pi 2} \| r_{\pi 1}))$$

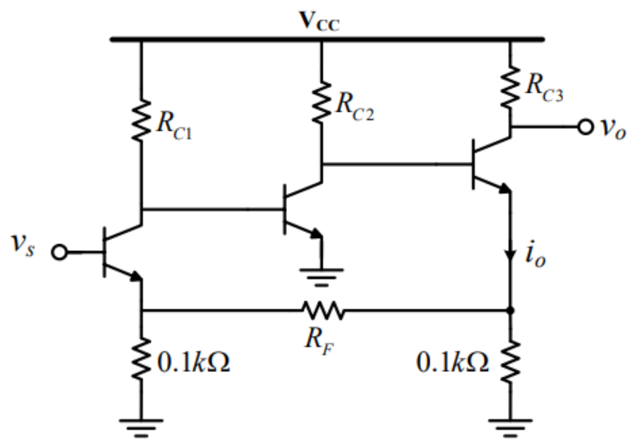
$$T = A\beta = \frac{(R \| R_s)(\beta_2 R_E g_{m2})}{(R_E \| r_{\pi 2})(\beta_2 + R_E g_{m2})}$$

$$A_i = \left(\frac{i_o}{i_s}\right)_{CL} = \frac{A_{OL}}{1 + T}$$

$$(R_{out})_{CL} = R_{o,OL}(1 + T)$$

$$R_{out} = R_C \| (R_{out})_{CL} \simeq R_C = R_{out}$$

6- In the following circuit, specify R_F so that $\frac{i_o}{v_S} = 0.1$. The gain of the main amplifier is assumed to be very large.



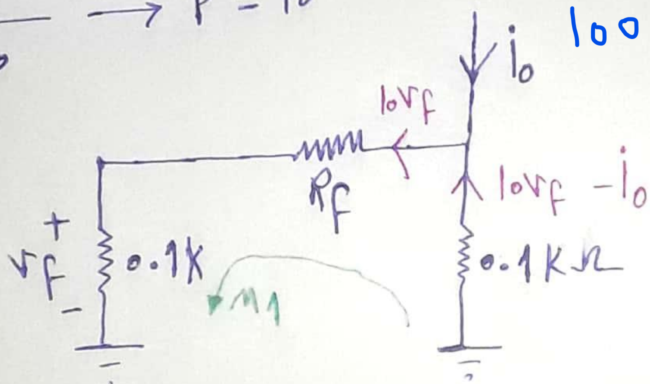
-6

$R_f = ?$ $\quad A_{oL} \gg 1$ $\quad \frac{i_o}{v_s} = \frac{1}{10}$

$$A_{oL} = \left(\frac{i_o}{v_s}\right)_{oL} \gg 1 \longrightarrow A_{CL} = \left(\frac{i_o}{v_s}\right)_{CL} = \frac{A_{oL}}{1+\beta A_{oL}}$$

$$\longrightarrow A_{CL} \simeq \frac{1}{\beta} \qquad \beta = \frac{v_f}{i_o}$$

$$\frac{1}{\beta} = \frac{1}{10} \longrightarrow \beta = 10\,\Omega = \frac{1}{100}K$$



$$KVL@M_1: \; v_f - 0.1 i_o + 10 v_f R_f + v_f = 0 \longrightarrow$$

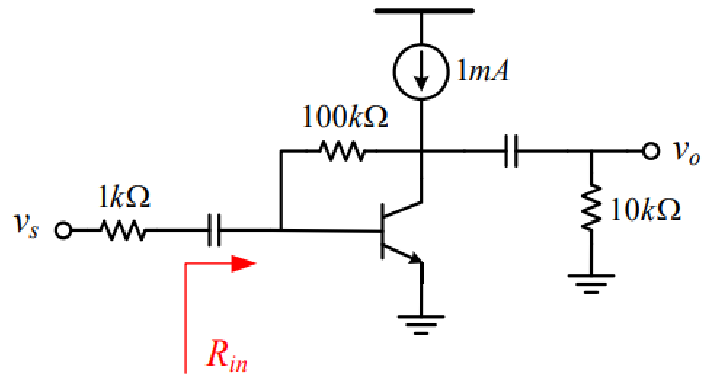
$$(2+10R_f)v_f = 0.1 i_o \longrightarrow \frac{v_f}{i_o} = \frac{1}{10(2+10R_f)} = \beta = \frac{1}{100}$$

$$\cancel{\beta_o = \frac{1}{10(2+10R_f)} \rightarrow 100(2+10R_f) = 1 \rightarrow 2+10R_f = \frac{1}{100}}$$

$$\cancel{\rightarrow R_f}$$

$$R_f = 0.8K$$

7- Calculate the voltage gain ($\frac{v_o}{v_S}$) and the input resistance (R_{in}) of the following circuit.



$$\begin{cases} v_T = 25mV \\ \beta = 100 \end{cases}$$

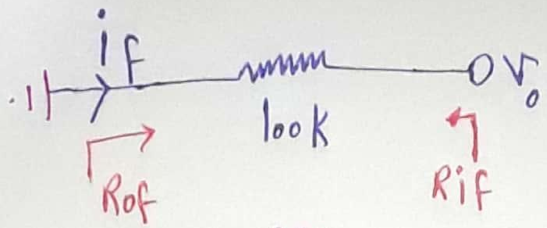
-7

$i_C \simeq 1mA \rightarrow g_m = 40mS$ $\quad$ $R_{in} = ?$ $\quad$ $? = \frac{v_o}{v_s}$

$r_\pi = 2.5k\Omega$

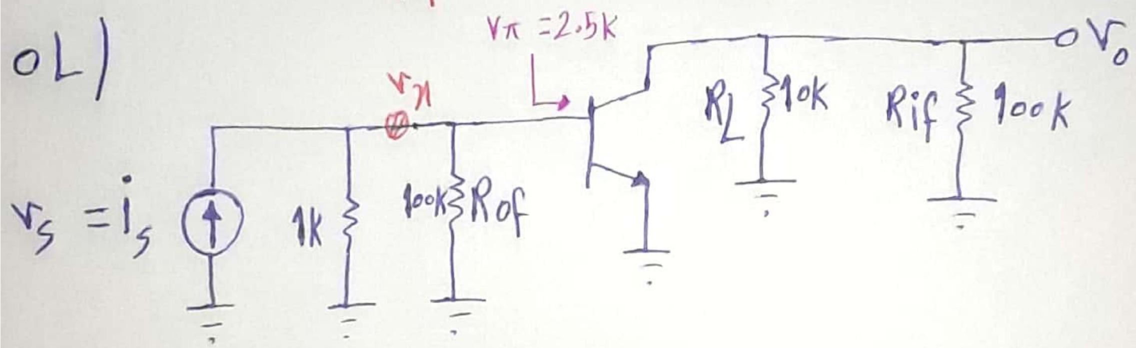
فیدبک ولتاژ موازی یا موازی موازی

$\underbrace{i_s - i_f}_{eror} = i_B$ $\quad$ $\beta = \frac{i_f}{v_o} = \frac{-1}{100} \frac{mA}{V}$



$R_{of} = R_{if} = 100k\Omega$

OL)



$$A_{OL} = \frac{v_o}{i_s} = \frac{v_o}{v_\pi} \times \frac{v_\pi}{i_s}$$

$$\frac{v_o}{v_\pi} = -g_m R_C = -400 \qquad \frac{v_\pi}{i_s} = 1k \| 100k \| 2.5k = 0.7k\Omega$$

$$A_{OL} = -280 \qquad R_{in,OL} = 0.7k\Omega \qquad T = A\beta = 2.8$$

$$A_{CL} = \frac{v_o}{i_s} = \frac{A_{OL}}{1+T} = \frac{-280}{1+2.8} = -73.68$$

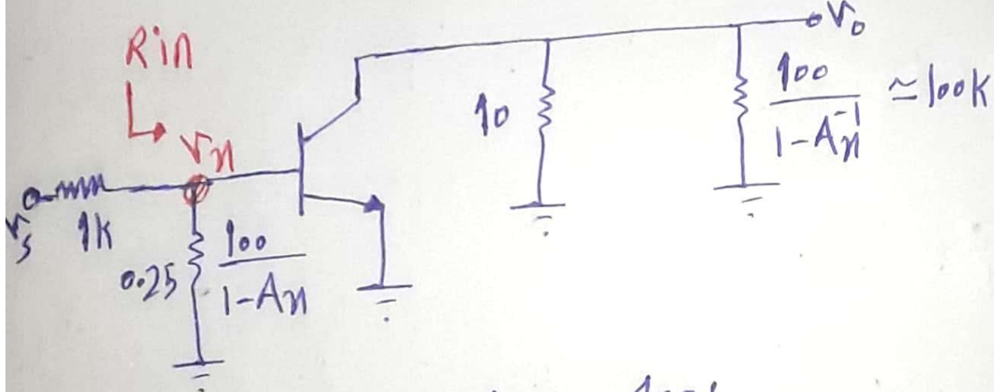
$$\frac{v_o}{v_s} = \frac{v_o}{i_s} \times \frac{i_s}{v_s} = \boxed{-73.68}$$

$$R_{in,CL} = \frac{R_{in,OL}}{1+T} = 0.2k\Omega$$

$$R_{in,CL} = R_{in} \| 1k \rightarrow R_{in} = 1k \| -R_{in,CL}$$

$$R_{in} = -1k \| +0.2k = +0.25k\Omega$$

چک کردن پاسخ با تحلیل:



$$A_x = -g_m R_C = -40 \times 10 = -400$$

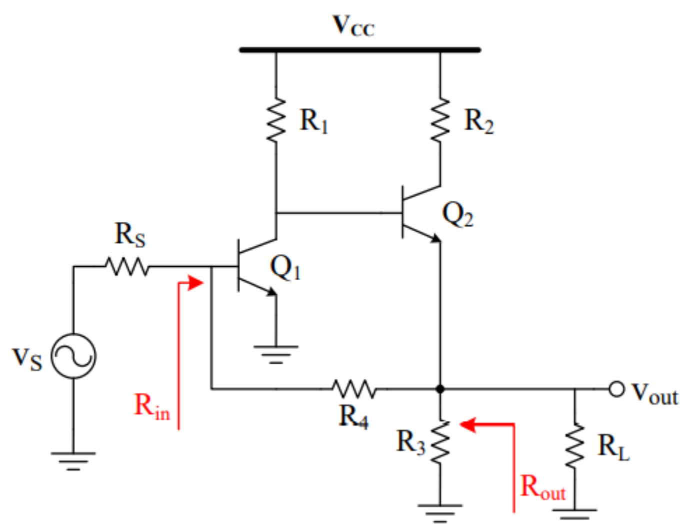
$$\frac{v_x}{v_s} = \frac{0.227}{1.227} = 0.185$$

$$\rightarrow \frac{v_o}{v_s} = A_x \times 0.185 = -74$$

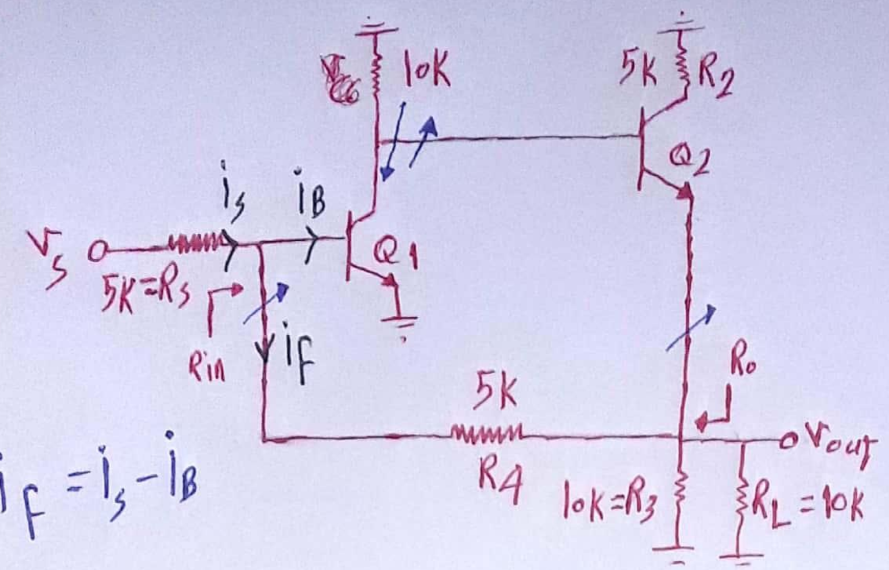
$$R_{in} = 0.25 \| 2.5 \simeq 0.25k\Omega$$

8- a) In the following circuit, prove that the feedback sign is negative. In addition, specify the type of the feedback configuration.

b) Calculate the voltage gain, input resistance and output resistance of the circuit.



$$\begin{cases} R_1 = R_3 = R_L = 10k\Omega \\ R_2 = R_S = R_4 = 5k\Omega \\ \beta = 100 \\ g_m = 40mA/V \\ V_A = \infty \\ V_{CC} = 10V \end{cases}$$



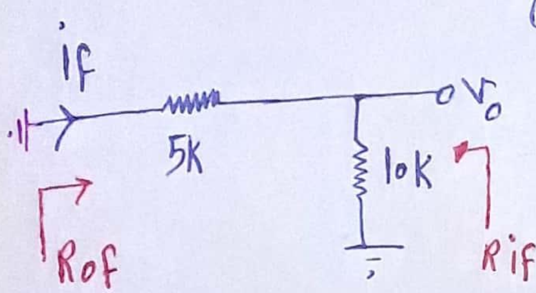
$$A_v = \frac{v_o}{v_{in}}$$

R_o

R_{in}

$$i_f = i_s - i_B$$

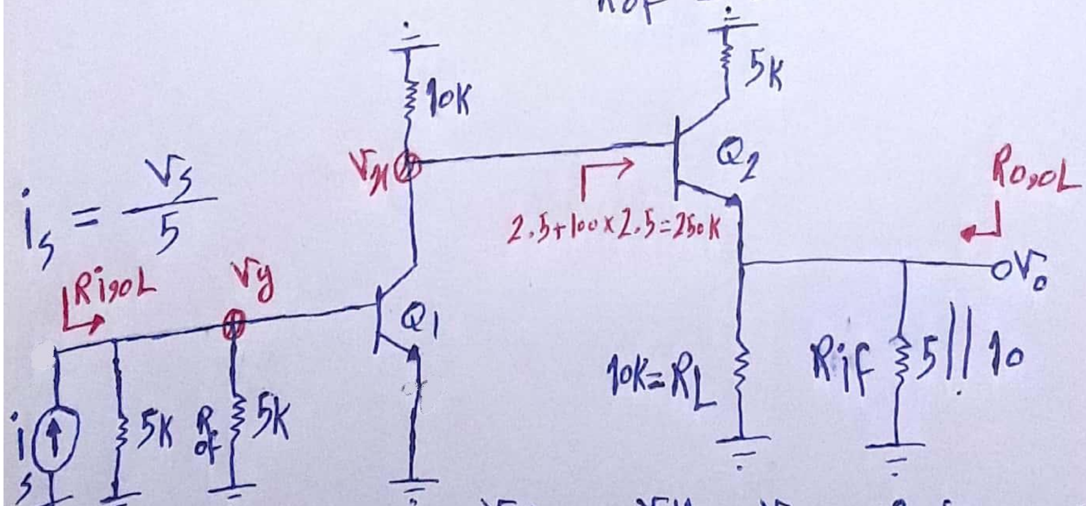
فیدبک ولتاژ : موازی با موازی موازی



$$\beta = \frac{i_f}{v_o} = \frac{-1}{5k}$$

$$R_{if} = 5 \| 10 = 3.333\,k\Omega$$

$$R_{of} = 5\,k\Omega$$



$$i_s = \frac{v_s}{5}$$

$$A_{oL} = \frac{v_o}{i_s} = \frac{v_o}{v_x} \times \frac{v_x}{v_y} \times \frac{v_y}{i_s} \quad \frac{v_o}{v_x} = \frac{2.5}{2.5 + \frac{1}{40}} = 1$$

$$\cancel{\frac{v_x}{v_y}} \quad \frac{v_x}{v_y} = -40 \times 10 = -400 \qquad \frac{v_y}{i_s} = 5 \| 5 \| 2.5 = 1.25\,k\Omega$$

$A_{OL} = -500\ k\Omega$

$R_{in,OL} = 1.25k\Omega$

$R_{o,OL} = 2.5 \parallel \left(\frac{1}{40} + \frac{10}{100}\right) = 119\Omega$

$T = A\beta = 100$

$$A_{CL} = \frac{A_{OL}}{1 + A\beta}$$

$$A_{CL} = \frac{-500}{1+100} = -4.95k\Omega = \frac{v_o}{i_s}$$

$$\frac{v_o}{v_s} = \frac{v_o}{i_s} \times \frac{i_s}{v_s} = -4.95 \times \frac{1}{5} = -0.99 = A_v = \frac{v_o}{v_s}$$

$$R_{in}|_{CL} = \frac{R_{in,OL}}{1+T} = \frac{1.25}{101} = 12.5\Omega$$

$(R_{in})_{CL} = 5k \parallel R_{in}$

$12.5\Omega = 5k \parallel R_{in}$

$12.5\Omega = R_{in}$

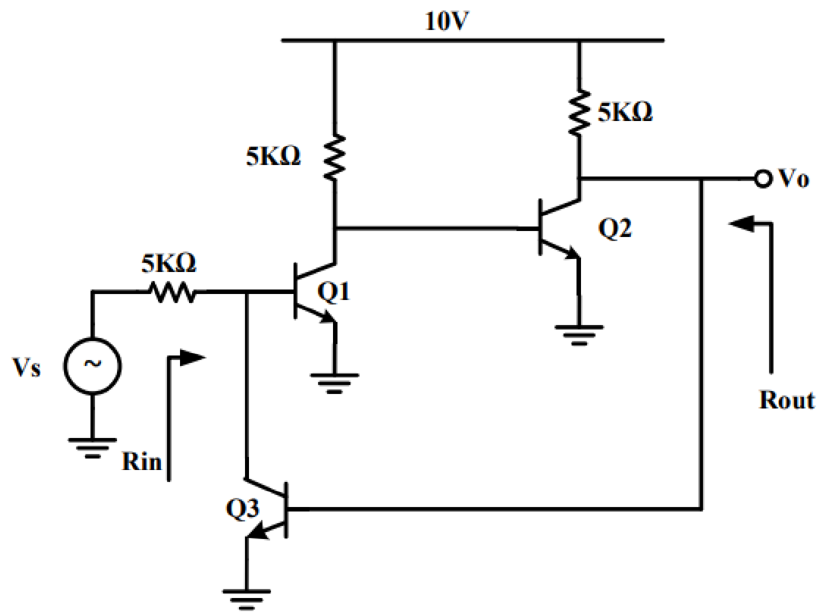
$$R_o|_{CL} = \frac{R_{o,OL}}{1+T} = 1.19\ \Omega$$

$R_o|_{CL} = R_L \parallel R_o \longrightarrow 1.19\ \Omega = 10k \parallel R_o \rightarrow$

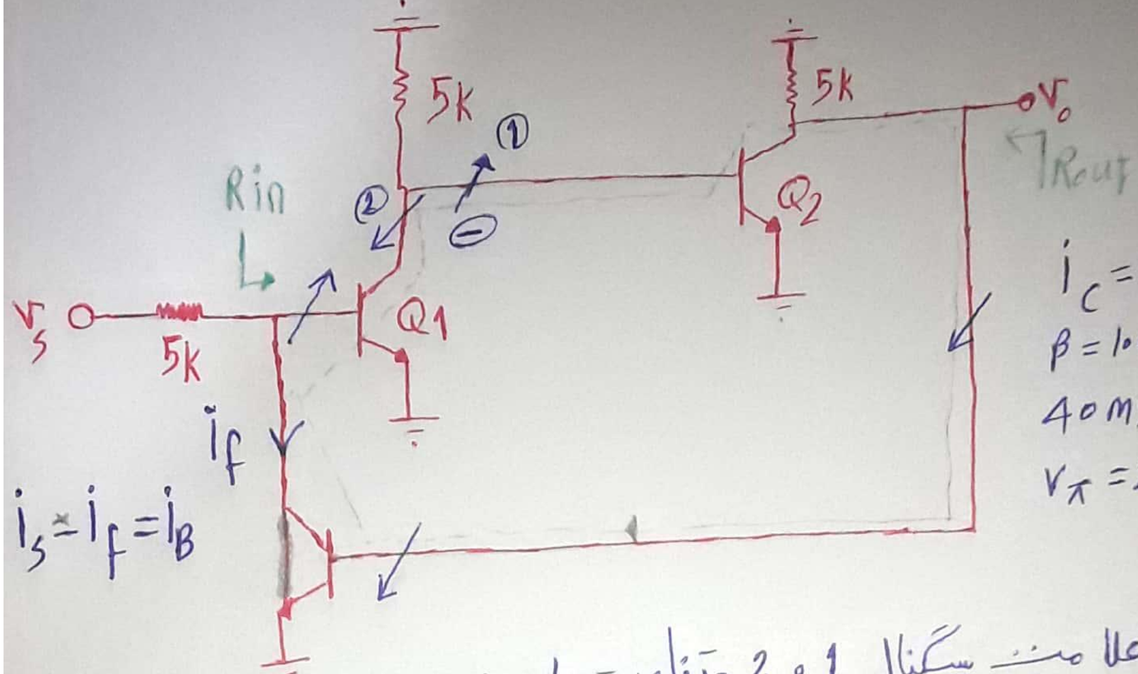
$R_o = 1.19\Omega$

9- In the following circuit, suppose that I_C=1 mA and β=100 for all of the transistors.

a) Specify the feedback loop of the circuit and show that the feedback sign is negative.
b) Specify the type of the feedback configuration.
c) Calculate the voltage gain.
d) Calculate the input and the output resistances (R_{in} and R_{out})



-9



$i_C = 1mA$

$\beta = 100$

$40mS = g_m$

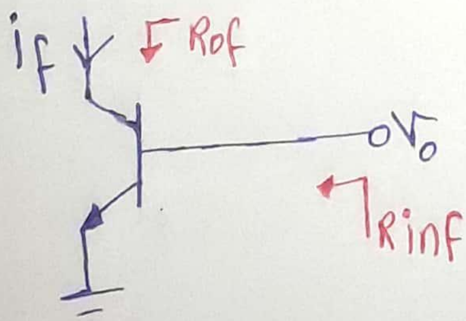
$r_\pi = 2.5k\Omega$

$i_s \simeq i_f = i_B$

a| علامت سیگنال 1 و 2 متفاوت است ← فیدبک منفی

b| فیدبک ولتاژ موازی یا موازی موازی

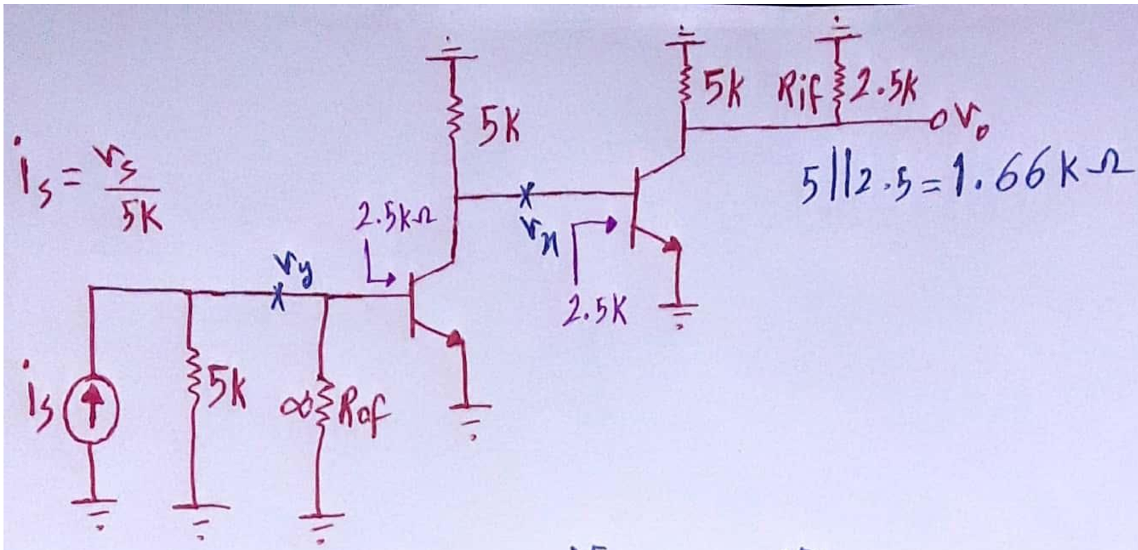
c و D| $A_v = \frac{v_o}{v_{in}} = ?$ $R_{out} = ?$ $R_{in} = ?$



$$\beta = \frac{i_f}{v_o} \rightarrow \beta = g_m = 40\frac{mA}{V}$$

$$R_{inf} = r_\pi = 2.5k\Omega$$

$$R_{of} = r_o = \infty$$



$$\frac{v_o}{i_s} = (A_v)_{OL} = \frac{v_o}{v_x} \times \frac{v_x}{v_y} \times \frac{v_y}{i_s}$$

$$\frac{v_o}{v_x} = -40 \times 1.66 = -66.4 \qquad \frac{v_y}{i_s} = 1.66\,k\Omega$$

$$\frac{v_x}{v_y} = -1.66 \times 40 = -66.4$$

$$A_{OL} = 7319\,k\Omega \qquad (R_{in})_{OL} = 1.66\,k\Omega \qquad (R_o)_{OL} = 1.66\,k\Omega$$

$$A_{CL} = \frac{v_o}{i_s} = \frac{A_{OL}}{1+T} \qquad T = A\beta = 292760 \gg 1$$

$$A_{CL} = \frac{1}{\beta} = \frac{1}{40}\,k\Omega = 25\,\Omega = \frac{v_o}{i_s}$$

$$\frac{v_o}{v_s} = \frac{v_o}{i_s} \times \frac{i_s}{v_s} = 25 \times \frac{1}{5000} = 5 \times 10^{-3} = \frac{1}{200} = \frac{v_o}{v_s}$$

$$(R_{in})_{CL} = \frac{1.66K}{1+T} = 5.67\,m\Omega \rightarrow 5.67\,m\Omega = R_{in} \| 5K$$

$$R_{in} = 5.67\,m\Omega \qquad (R_o)_{CL} = R_o = \frac{1.66k}{1+T} = 5.67\,m\Omega = R_o$$