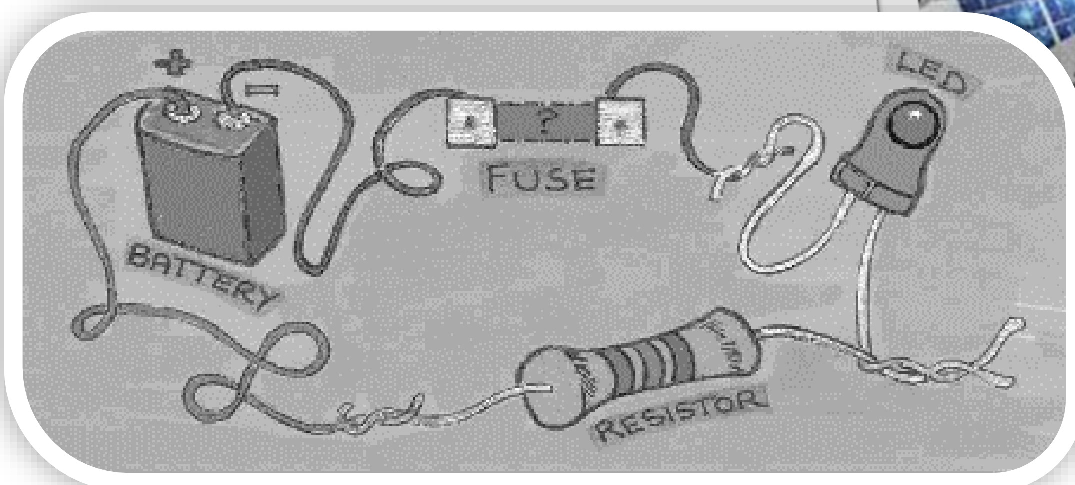
EHB222E QUESTIONS
9^{th} week

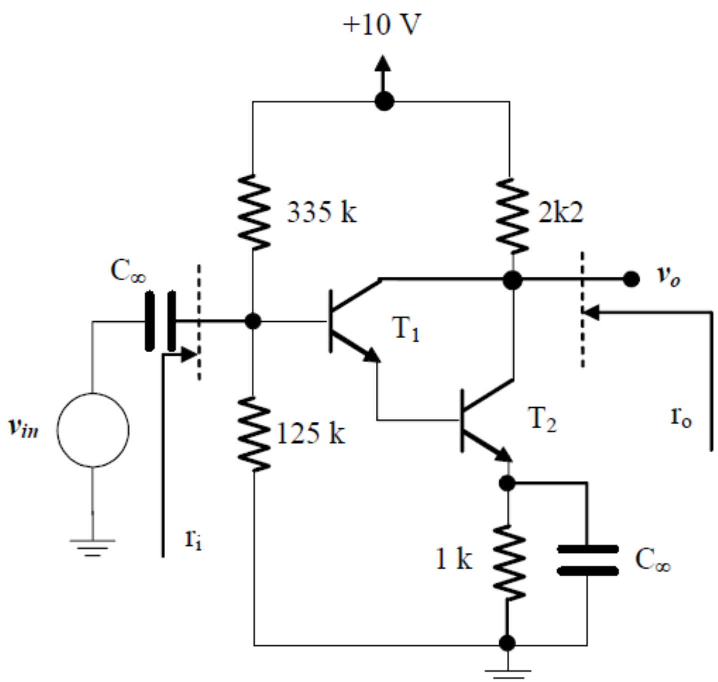


For the circuit shown, transistor parameters for identical T_1 and T_2 are $V_A = \infty$, V_T = 25 mV, $|V_{BE}|$ = 0,6 V, and $h_{fe} = h_{FE} = \beta = 100$.

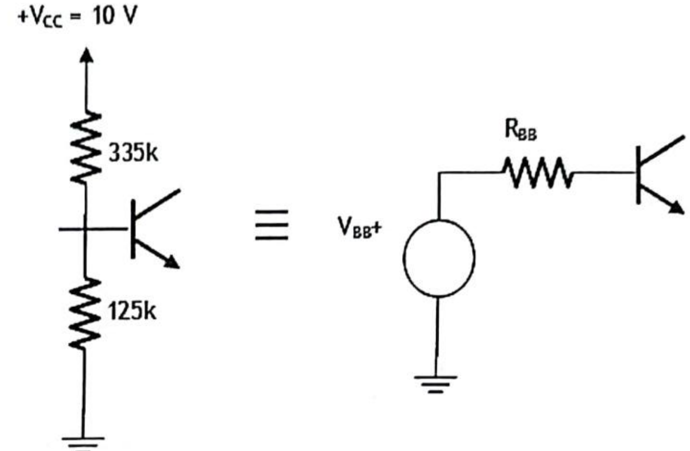
a. Determine DC collector currents.

b. Find the small signal voltage gain v_o/v_{in}.

c. Determine the input and output resistances.

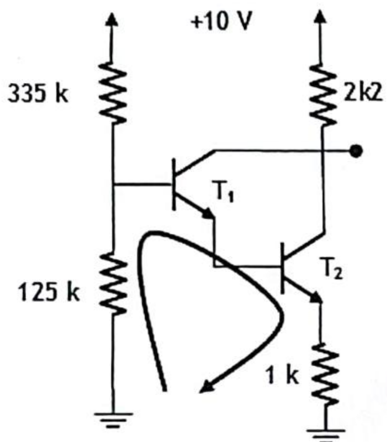


1. Yandaki şekilde görüldüğü gibi



$R_{BB} = 335k \parallel 125k = \underline{\underline{91k}}$ ve

$$V_{BB} = \frac{125k}{125k + 335k} V_{CC} = \underline{\underline{2{,}72V}}$$



olarak bulunduktan sonra V_{BB}, R_{BB}, T_1, T_2 ve 1k'lık R_E'yi içeren çevremin denklemi yazılırsa

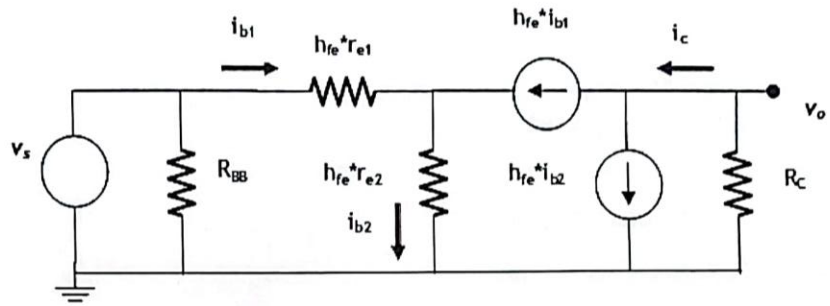
$V_{BB} = (335k \parallel 125k) I_{B1} + V_{BE1} + V_{BE2} + 1k(h_{FE}+1) I_{B2}$, burada

$I_{B2} = (h_{FE}+1) I_{B1}$ olduğu için

$$I_{B1} = \frac{V_{BB} - V_{BE1} - V_{BE2}}{(335k \parallel 125k) + (h_{FE}+1)^2 1k} = \frac{2{,}72V - 0{,}6V - 0{,}6V}{91k + 101^2 1k} = 0{,}147\,\mu A \text{ dolayısıyla}$$

$$I_{C1} = h_{FE} * I_{B1} = \underline{\underline{14{,}7\,\mu A}}; I_{C2} = h_{FE} * I_{B2} = h_{FE}(h_{FE}+1) I_{B1} = \underline{\underline{1{,}49mA}}$$

$$r_{e1} = \frac{V_T}{I_{C1}} = \underline{\underline{1k7}}; r_{e2} = \frac{V_T}{I_{C2}} = \underline{\underline{16{,}8\Omega}} \text{ bulunur.}$$



Devrenin kazanç ifadeleri için önce küçük işaret devresini yandaki gibi çizmek gerekir.

$v_o = -R_C i_c$ ve $i_c = h_{fe} i_{b1} + h_{fe}(h_{fe}+1) i_{b1} = h_{fe}(h_{fe}+2) i_{b1}$

ayrıca $v_s = h_{fe} r_{e1} i_{b1} + h_{fe} r_{e2} i_{b2} = h_{fe} r_{e1} i_{b1} + \dfrac{h_{fe} r_{e1}}{h_{fe}+1}(h_{fe}+1) i_{b1} = 2 h_{fe} r_{e1} i_{b1}$ olduğundan

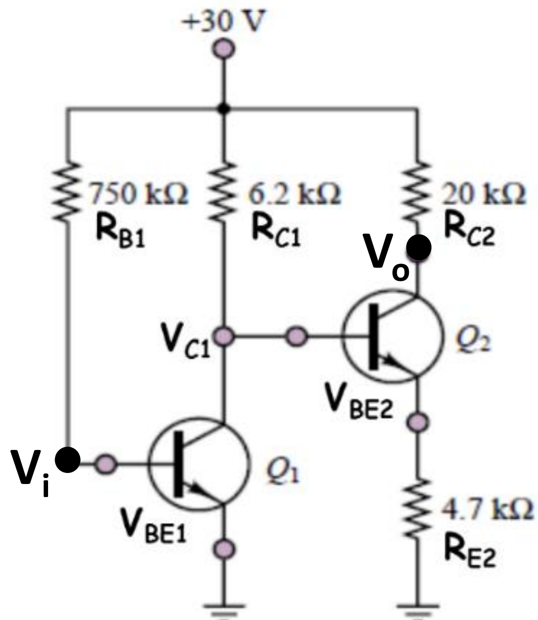
$\dfrac{v_o}{v_s} = -\dfrac{R_C h_{fe}(h_{fe}+2)}{2 h_{fe} r_{e1}} = \underline{\underline{-66{,}2}}$; diğer yandan $r_i = R_{BB} \,||\, \dfrac{v_s}{i_{b1}}$, $r_i{}^* = \dfrac{v_s}{i_{b1}} = 2 h_{fe} r_{e1} = \underline{\underline{339k}}$ ve

$r_i = R_{BB} \,||\, \dfrac{v_s}{i_{b1}} = \underline{\underline{71k8}}$ olarak bulunur.

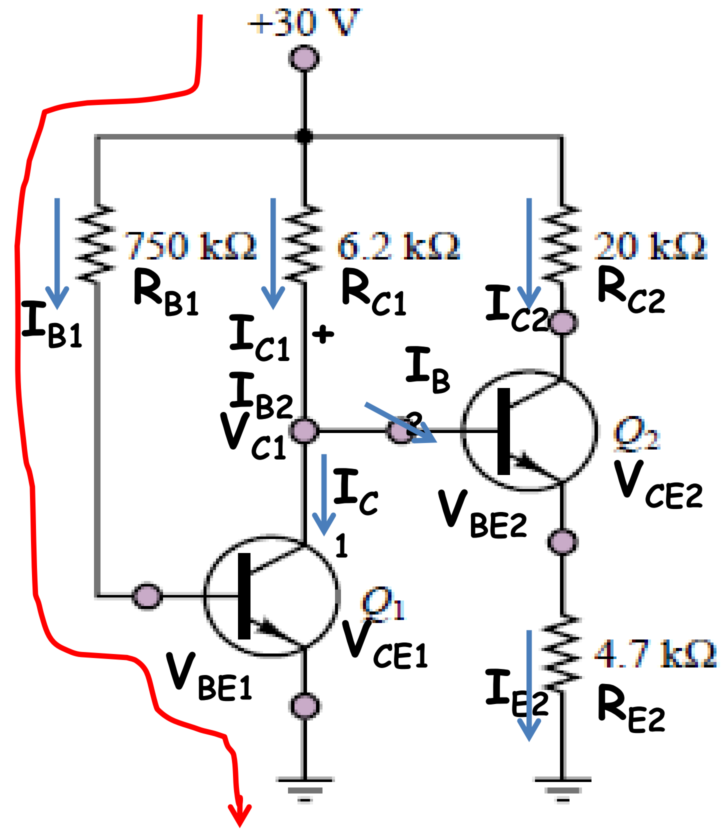
Devre kolektör çıkışlı olduğu için $r_o = R_C = \underline{\underline{2k2}}$ dir.

For the circuit shown, transistor parameters for identical Q_1 and Q_2 are $V_A = \infty$, $V_T = 25$ mV, $|V_{BE}| = 0,6$ V, and $\beta = 100$.

a. Determine DC collector currents.
b. Find the small signal voltage gain v_o/v_{in}.
c. Determine the input and output resistances.



Problem BJT: - For the circuit below assume both transistors are silicon-based with β = 100. Determine: **a)** I_{C1}, V_{C1}, V_{CE1}. **b)** I_{C2}, V_{C2}, V_{CE2}.



- **Soln:**

  Assume $V_{BE} = V_{BE1} = V_{BE2} = 0.7V$

- **Part (a): -** Apply KVL along the path (red line).

$$-30 + I_{B1} * R_{B1} + V_{BE1} = 0$$

$$I_{B1} = \frac{30 - 0.7}{750 * 10^3} = 39.07\,\mu A$$

$$I_{C1} = \beta * I_{B1} = 3.907\,mA$$

- **Part (a) contd.:** - Apply KVL along the path (red line).

We know that $30-(I_{C1}+I_{B2})R_{C1}-V_{BE2}-I_{E2}R_{E2}=0$

substituting we get $I_E=(\beta+1)I_B$

$$30-24.2234-I_{B2}R_{C1}-0.7-(\beta+1)I_{B2}R_{E2}=0$$

$$5.0766-I_{B2}(R_{C1}+101*R_{E2})=0$$

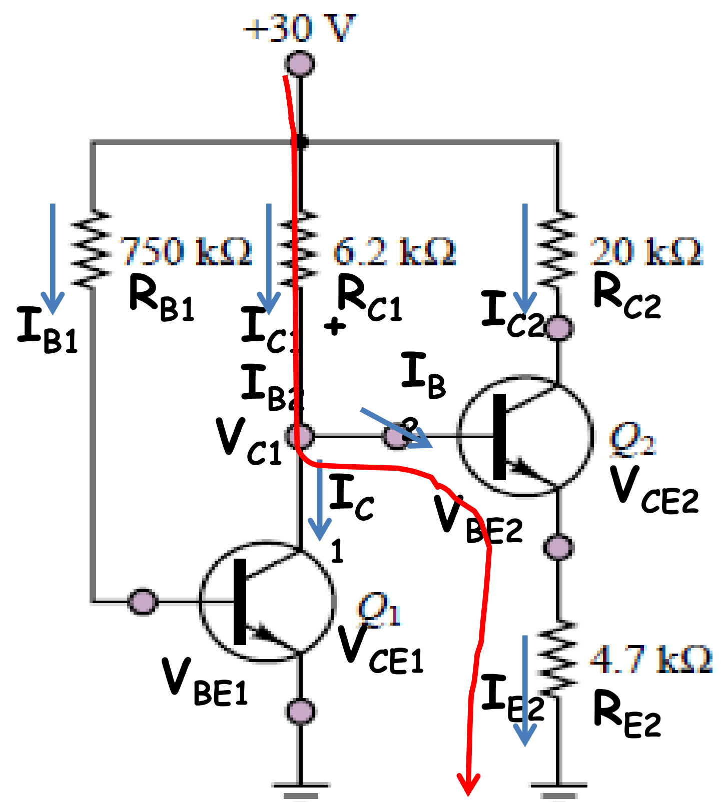
$$\Rightarrow I_{B2}=10.559\mu A$$

$$V_{C1}=30-(I_{C1}+I_{B2})*R_{C1}$$

$$V_{C1}=30-(3.907+0.010559)*6.2$$

$$=5.7111\ [V]$$

$$V_{CE1}=V_{C1}=5.7111V$$



- **Part (b): -** Apply KVL along the path (red line).

$$I_{E2} = (1+\beta)I_{B2} = 101*10.559\mu A = 1.0662mA$$

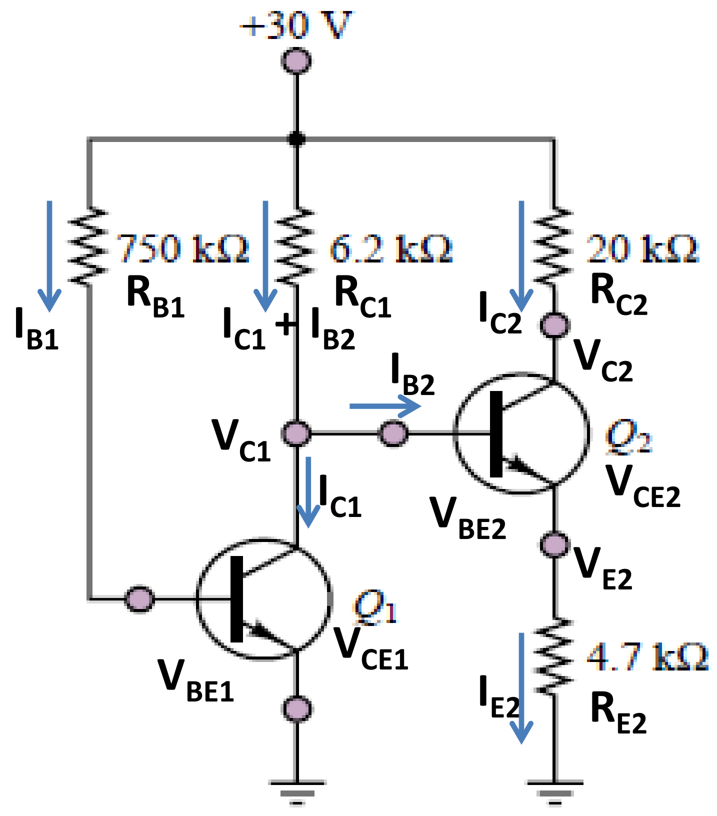
$$I_{C2} = I_{B2}\beta = 1.0556\,mA$$

$$V_{C2} = 30 - I_{C2}R_{C2}$$

$$V_{C2} = 30 - 1.0556 * 20 = 8.888V$$

$$V_{E2} = I_{E2}R_{E2} = 5.0111V$$

$$V_{CE2} = V_{C2} - V_{E2} = 3.8769\,V$$



Example

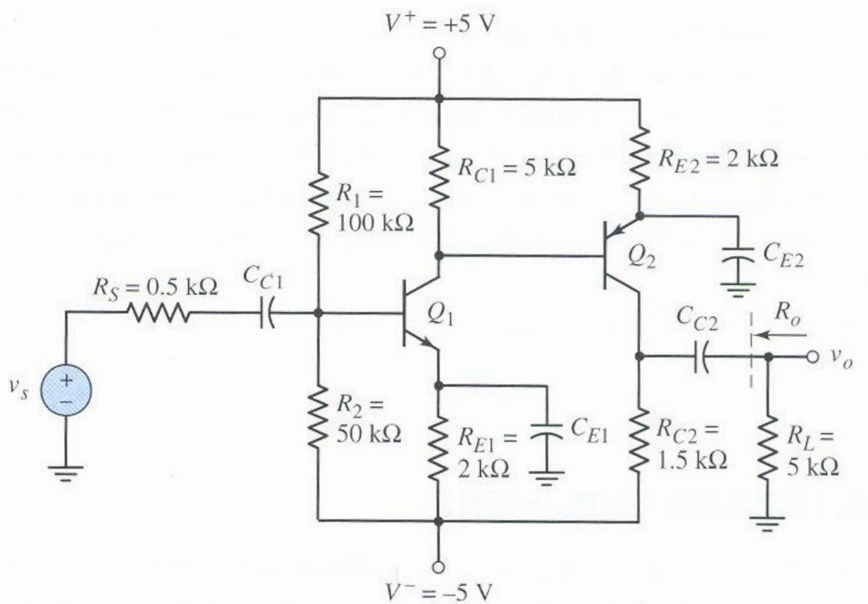
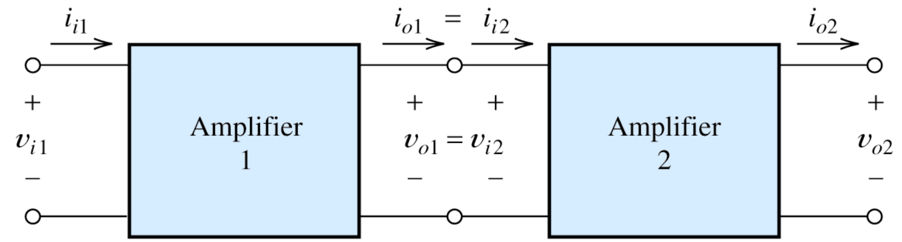


Figure 4.60 A two-stage amplifier in a cascade configuration



Cascade connection of two amplifiers.

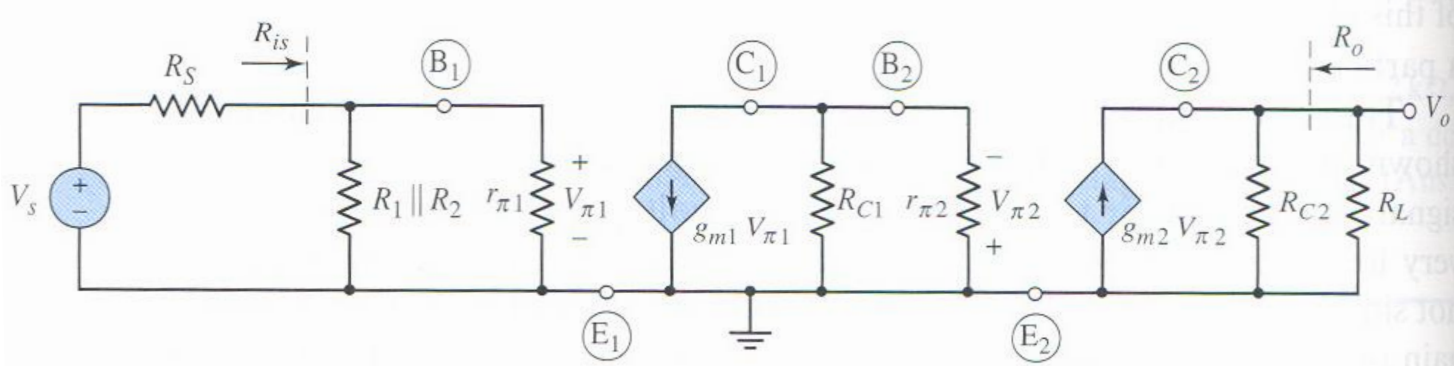


Figure 4.61 Small-signal equivalent circuit of the cascade configuration

Cascade Connection (cont.)

Small signal gain: $A_V = A_{V1} A_{V2}$ $\quad V_{\pi 1} = V_i,\ V_{\pi 2} = -V_{01}$

$$V_{O1} = -g_{m1} V_i (R_{C1} // r_{\pi 2})$$

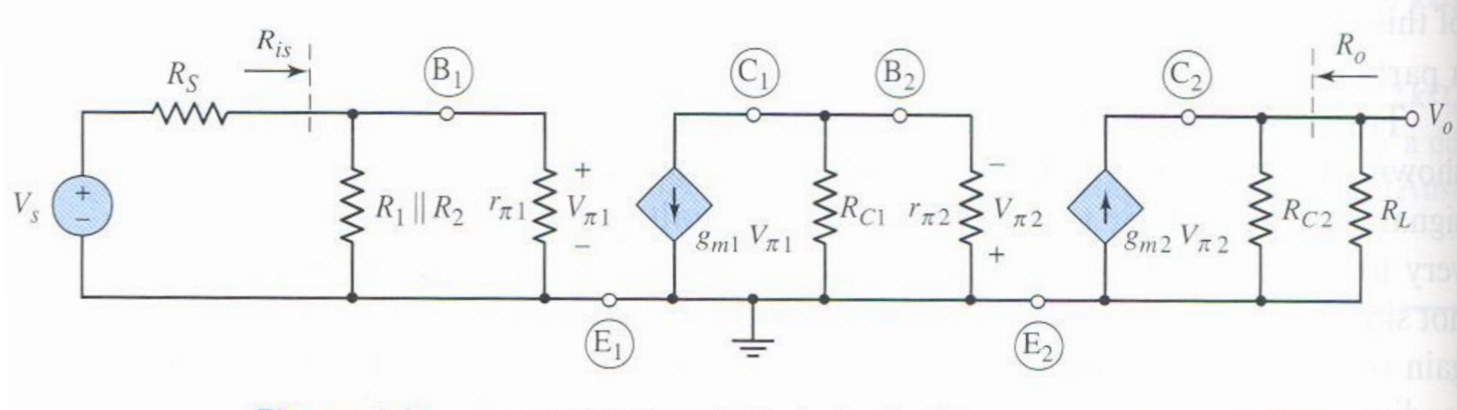
$$V_O = -g_{m2} V_{O1} (R_{C2} // R_L)$$

$$A_V = \frac{V_o}{V_i} = (-g_{m1}\ (R_{C1} // r_{\pi 2}))\ \ (-g_{m2}(R_{C2} // R_L))$$

$$A_V = \frac{V_o}{V_S} = g_{m1}\ (R_{C1} // r_{\pi 2})\ \ g_{m2}(R_{C2} // R_L)(\frac{R_{is}}{R_{is+}R_S})$$

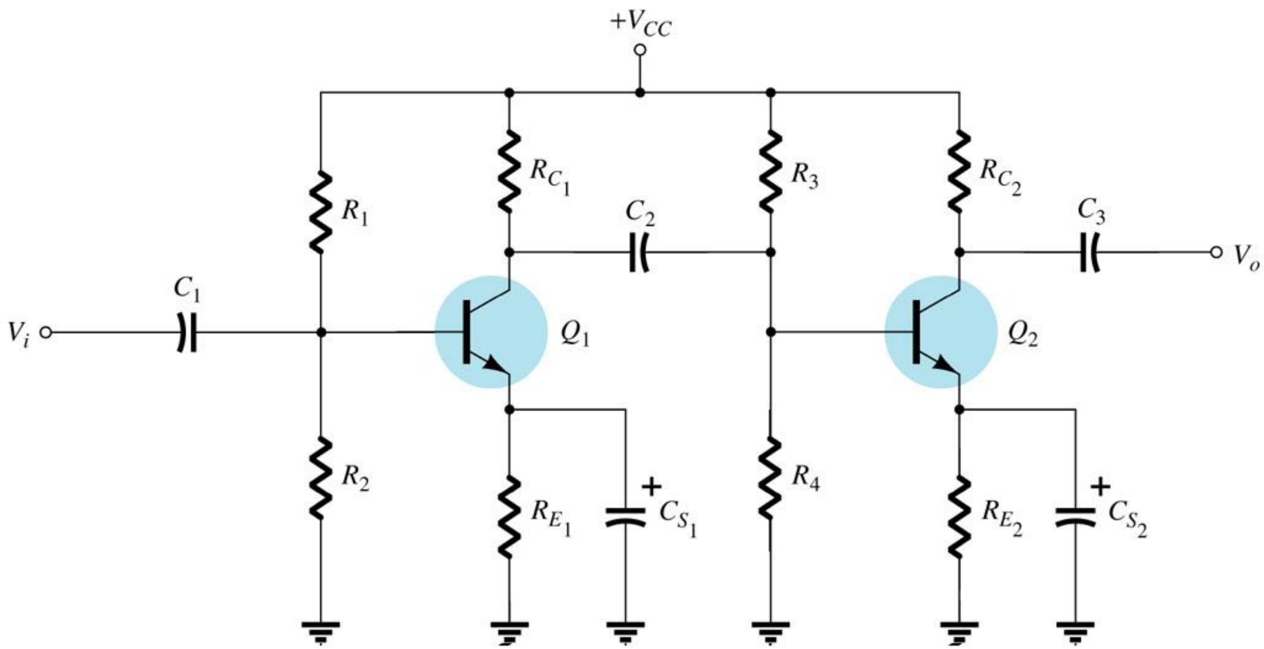
Input resistance: $R_{is} = R_1 // R_2 // r_{\pi 1}$

Output resistance: $V_s = 0$ $\quad v_{\pi 1} = v_{\pi 2} = 0$ $\quad R_0 = R_{C2}$



$V_A = \infty$

Exercise

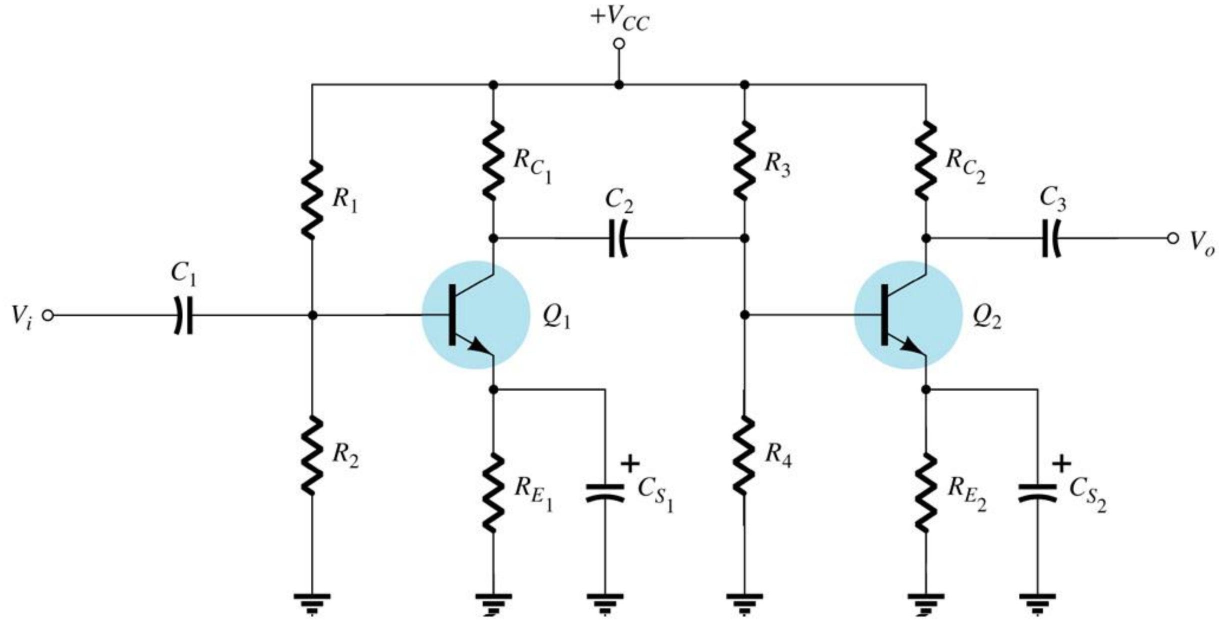


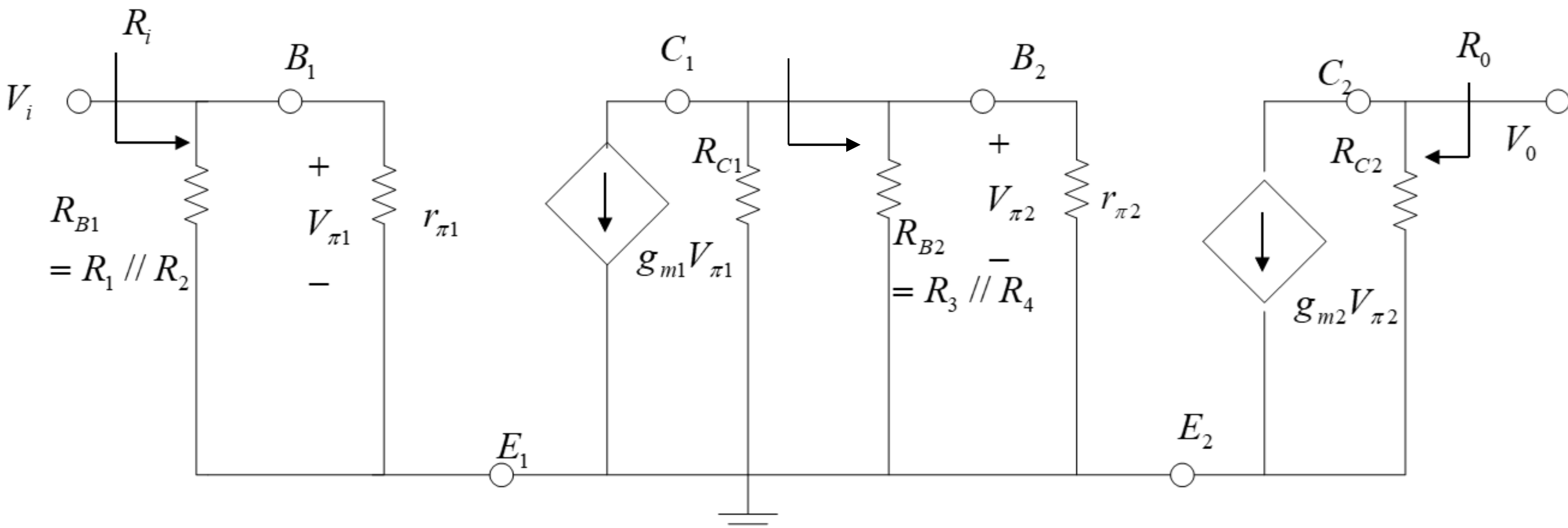
Draw the ac equivalent circuit and calculate the voltage gain, input resistance and output resistance for the cascade BJT amplifier in above Figure. Let the parameters are:

$$V_{CC} = 20V, \beta_{Q1} = \beta_{Q2} = 200, V_{BE(ON)} = 0.7V, r_0 = \infty$$

$$R_1 = R_3 = 15k\Omega, R_2 = R_4 = 4.7k\Omega, R_{C1} = R_{C2} = 2.2k\Omega, R_{E1} = R_{E2} = 1k\Omega$$

Solution





Ac equivalent circuit for cascade amplifier

Solution:

DC analysis:
At Q1:

$$I_{BQ1} = 19.89\,\mu A$$

$$I_{CQ1} = 3.979\,mA$$

At Q2:

$$I_{BQ2} = 19.89\,\mu A$$

$$I_{CQ2} = 3.979\,mA$$

AC analysis:
At Q1:

$$r_{\pi 1} = 1.307\,k\Omega$$

$$g_{m1} = 0.153\,S$$

At Q2:

$$r_{\pi 2} = 1.307\,k\Omega$$

$$g_{m2} = 0.153\,S$$

Solution:

From the ac equivalent circuit:

At Q1, the voltage gain is: $A_{VQ1} = \dfrac{V_{0Q1}}{Vi} = -g_m(R_{C1} // R_{i2})$

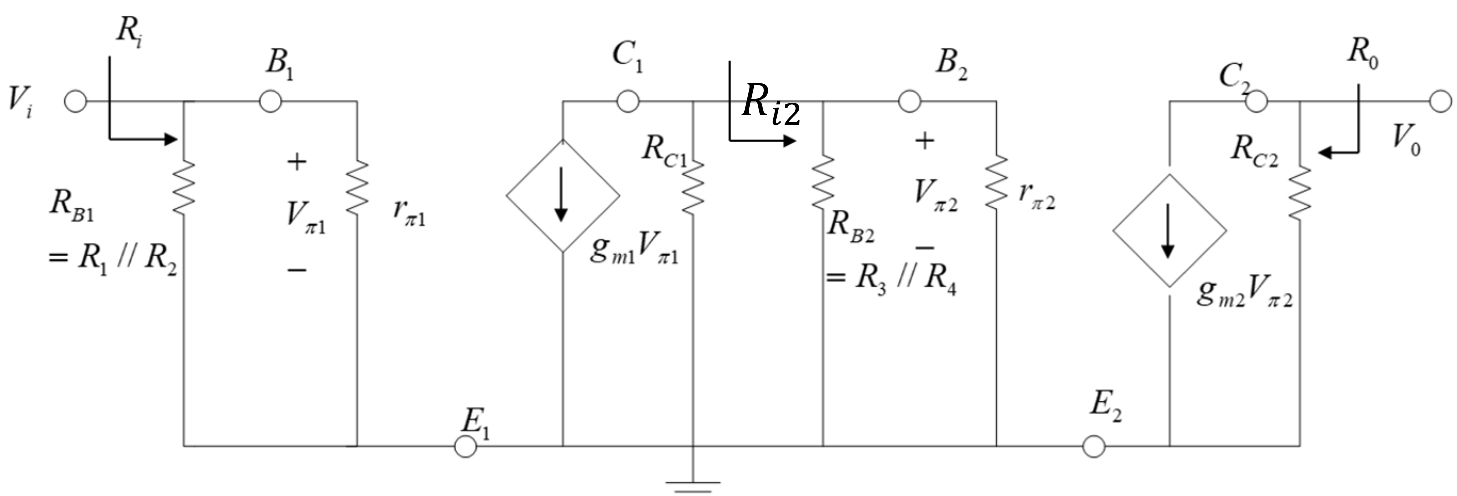
Where V_{0Q1} is the voltage looking to the Q1 transistor

and R_{i2} is the resistance looking into Q2 transistor

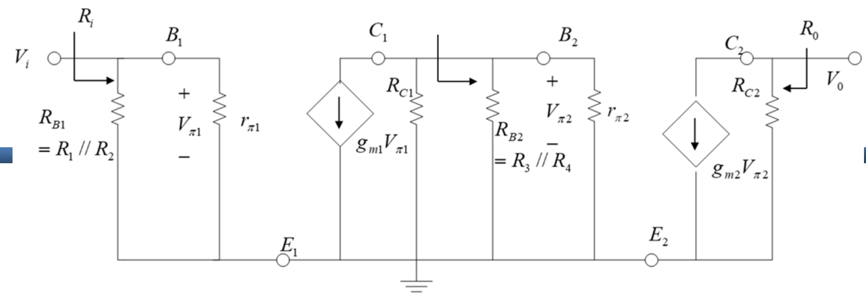
$$R_{i2} = R_{B2}//r_{\pi 2} = 15k//4.7k//1.307k = 957.36\Omega$$

The voltage gain at Q1 is:

$$A_{VQ1} = -0.153(2.2k // 957.36) = -102.06$$



Solution:



From the ac equivalent circuit:
At Q2, the voltage gain is:

$$A_{VQ2} = \frac{V_0}{V_{iQ2}} = -g_m(R_{C2})$$

Where V_{iQ2} is the voltage looking into the Q2 transistor

Therefore, the voltage gain at Q2 is:

$$A_{VQ2} = -0.153(2.2k) = -336.6$$

The overall gain is then,

$$A_V = A_{VQ1} A_{VQ2} = (-102.06)(-336.6) = 34{,}353$$

** The large overall gain can be produced by multistage amplifiers!!
So, the main function of cascade stage is to provided the larger overall gain

Solution:

From the ac equivalent circuit:

The input resistance is:

$$R_i = R_1 \,//\, R_2 \,//\, r_{\pi 1} = 15k \,//\, 4.7k \,//\, 1.307\,k$$

$$= 957.36\Omega$$

The output resistance is: $R_o = R_{C2} = 2.2k\Omega$