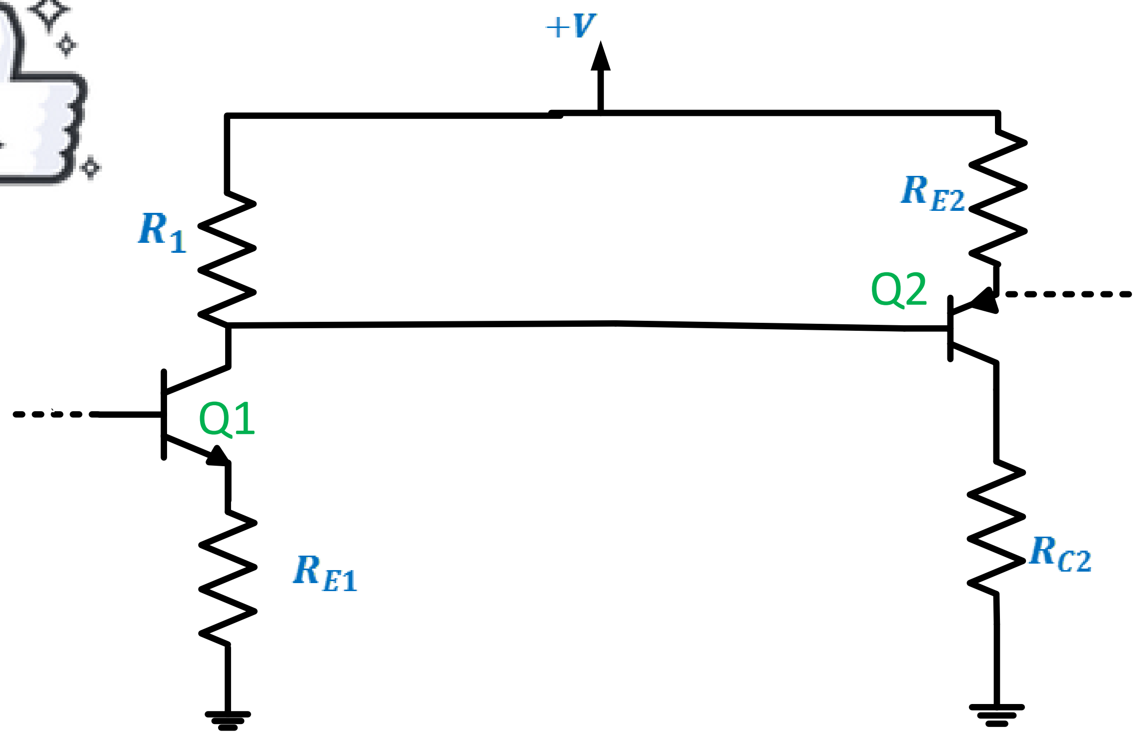
2) Direct – coupled multistage Amplifier

Advantages



- Used in differential and operational amplifier .

- Used in low and high frequency applications .

Darlington compound configuration

DC Analysis :

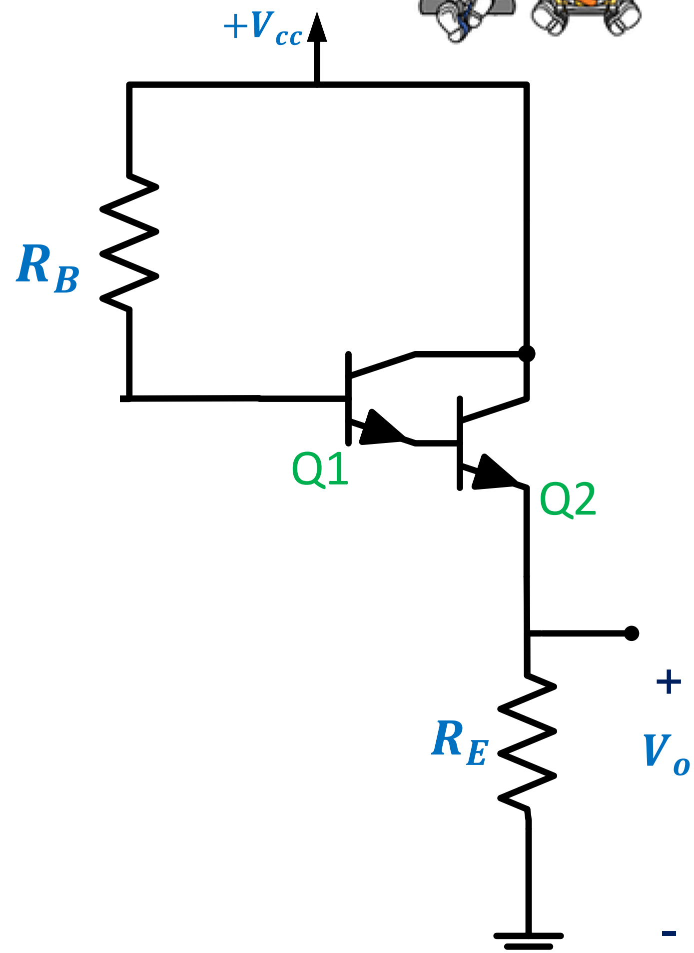
$$V_{cc} = R_B I_{B1} + V_{BE1} + V_{BE2} + R_E I_{E2}$$

$$I_{E2} = (\beta_2+1)\ I_{B2}$$

$$I_{B2} = I_{E1}$$

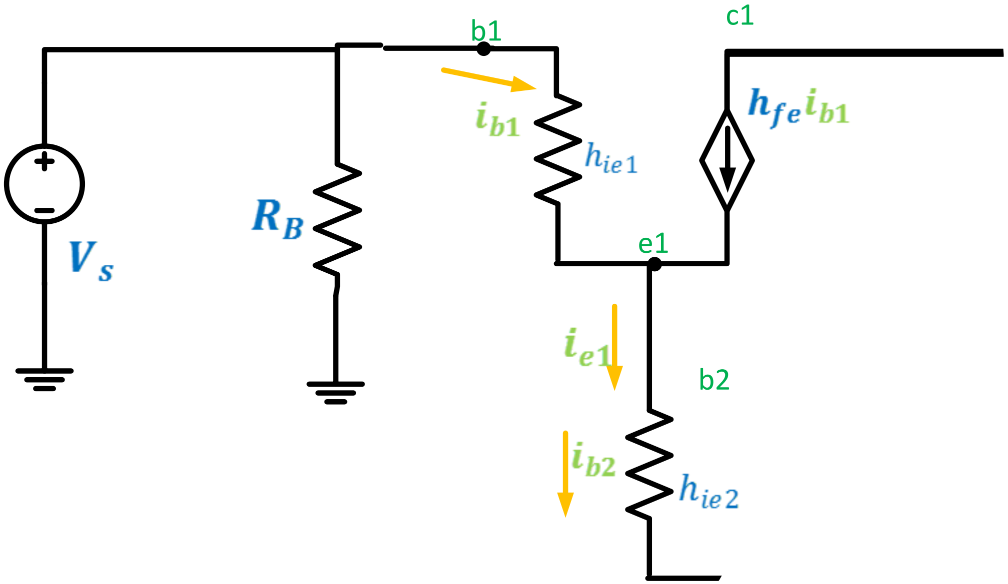
$$I_{E1} = (\beta_1+1)\ I_{B1}$$

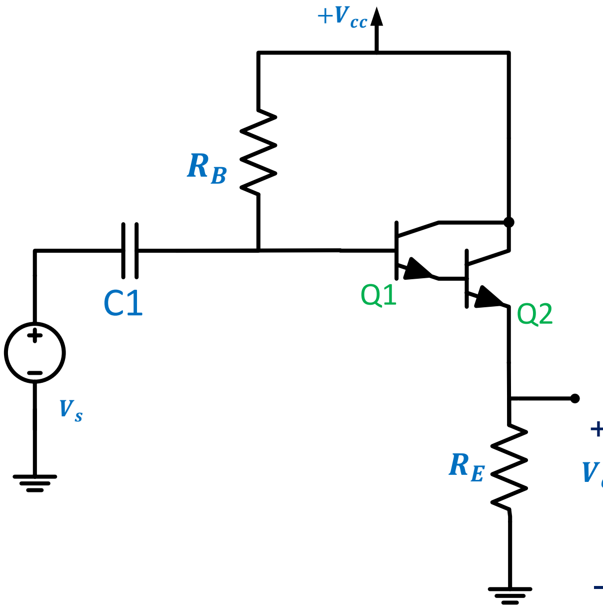
$$\therefore I_{E2} = (\beta_2+1)\ (\beta_1+1)\ I_{B1}$$



Darlington compound configuration

Ac small signal equivalent circuit





Darlington compound configuration

$$A_i = \frac{i_O}{ib_1} = \frac{ie_2}{ib_1}$$

$$ie_2 = (1+h_{fe2})\, ib_2$$

$$ib_2 = ie_1$$

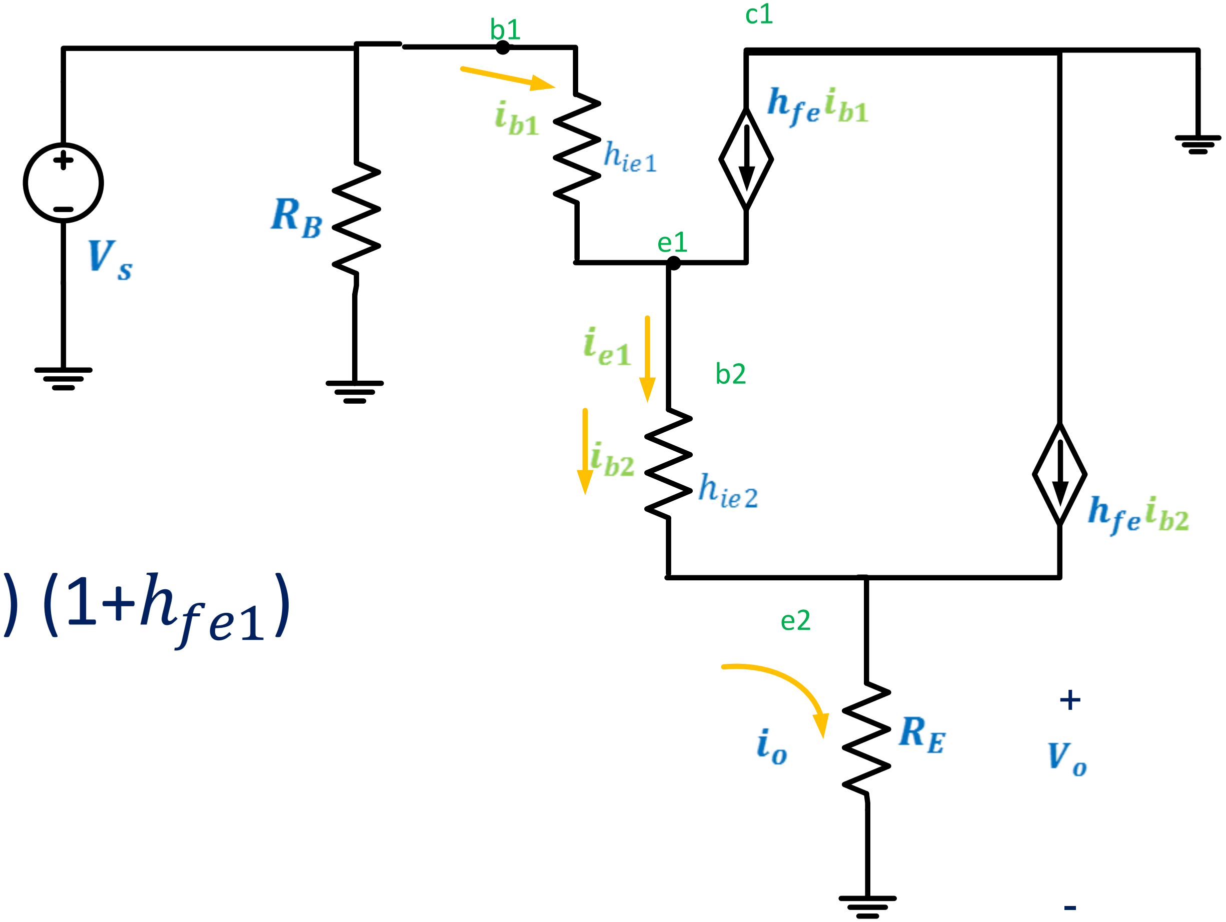
$$ie_1 = (1+h_{fe1})\, ib_1$$

$$A_i = \frac{i_O}{ib_1} = (1+h_{fe2})\,(1+h_{fe1})$$

$$A_v = \frac{V_O}{V_S}$$

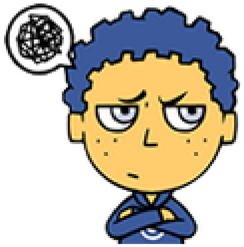
$$V_O = R_{\boldsymbol{E}} i_O$$

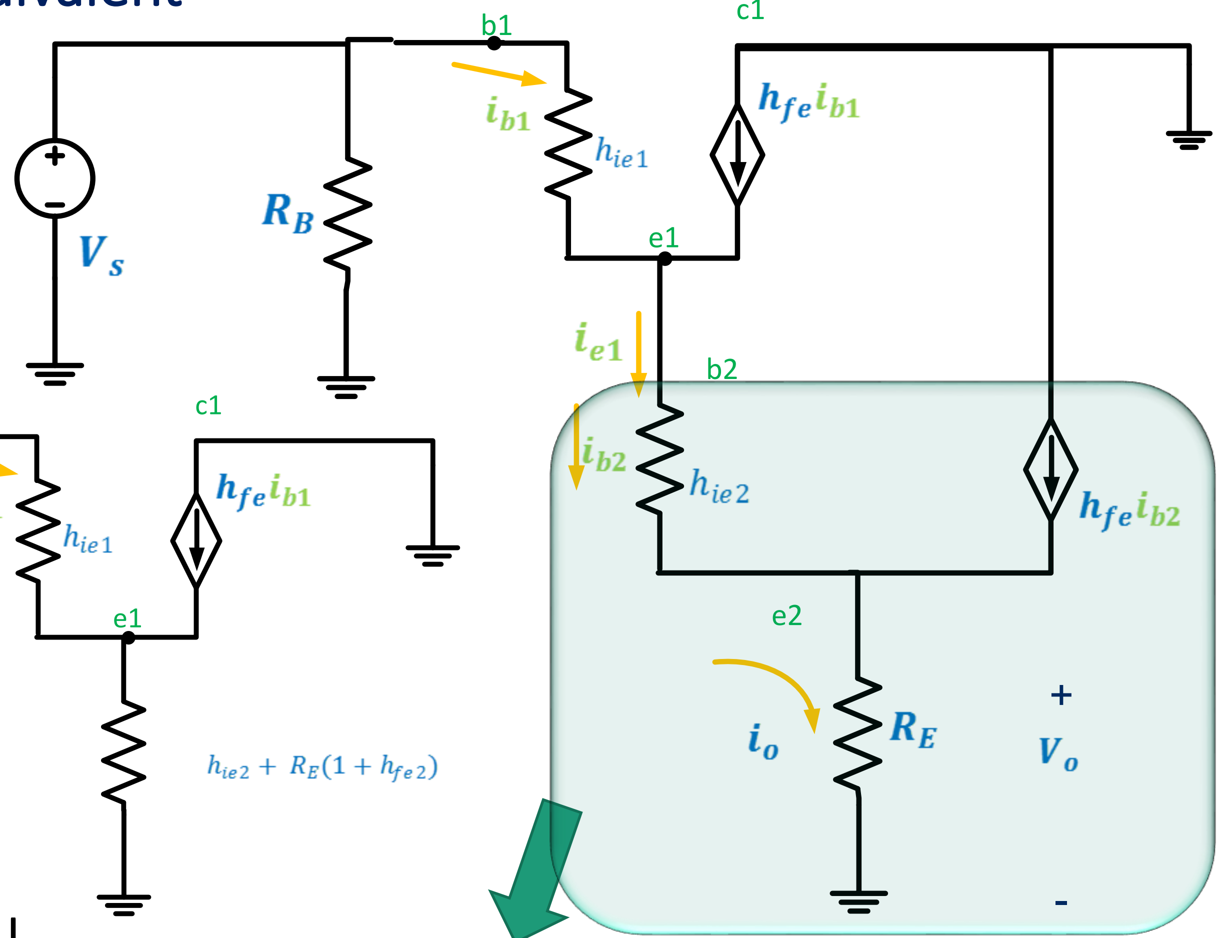
$$i_O = (1 + h_{fe2})\,(1 + h_{fe1}) ib_1$$

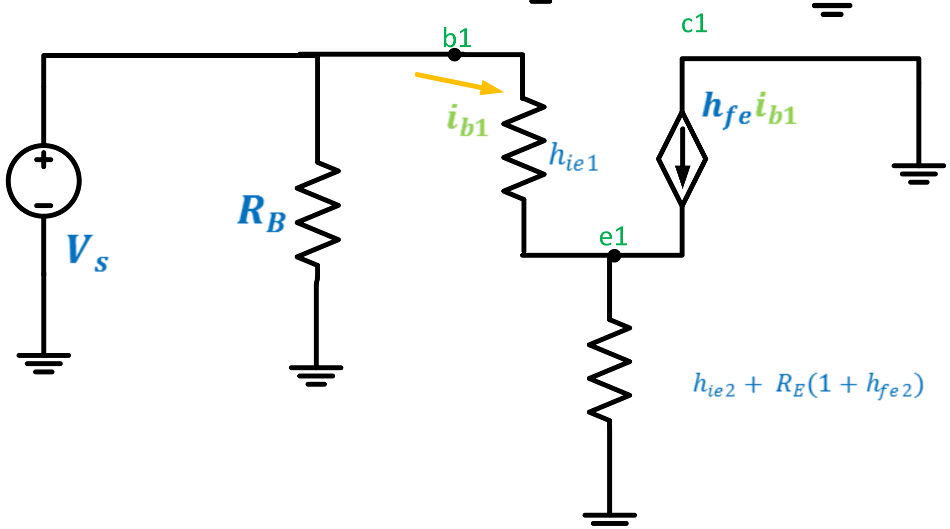


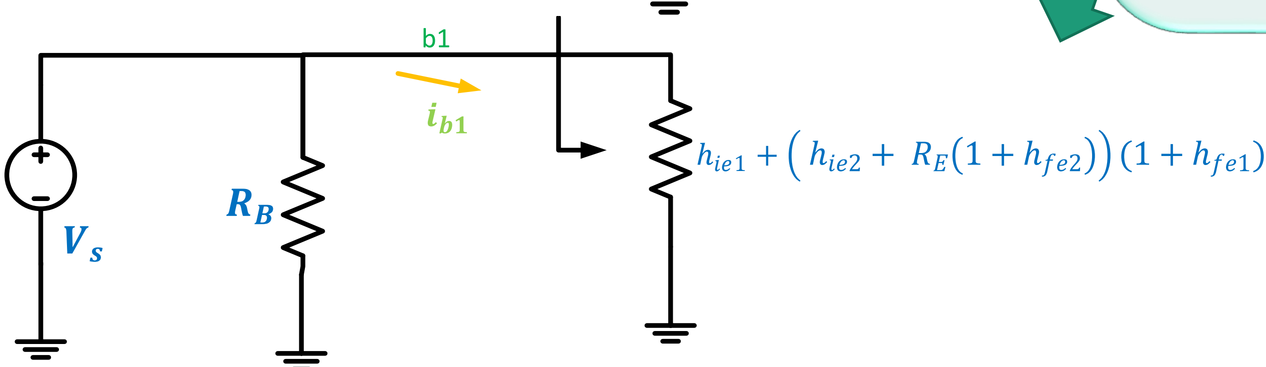
Darlington compound configuration

To find $ib_1 \rightarrow$ **base equivalent**



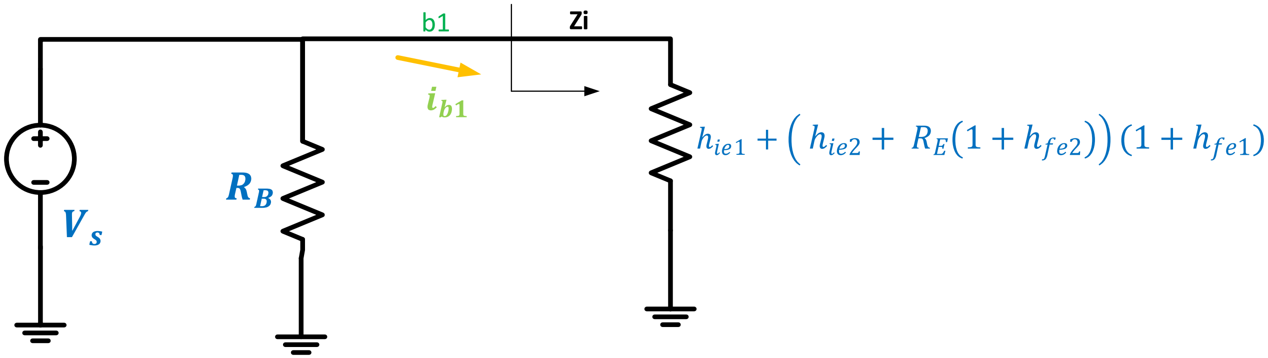




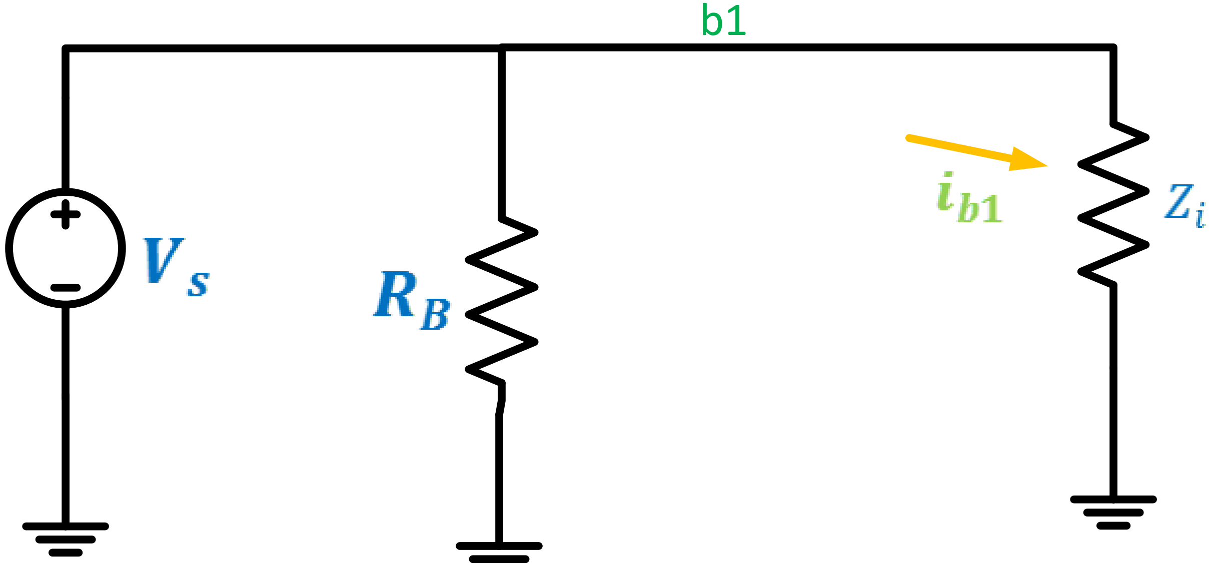


Darlington compound configuration

$$ib_1 = \frac{V_S}{Z_i}$$



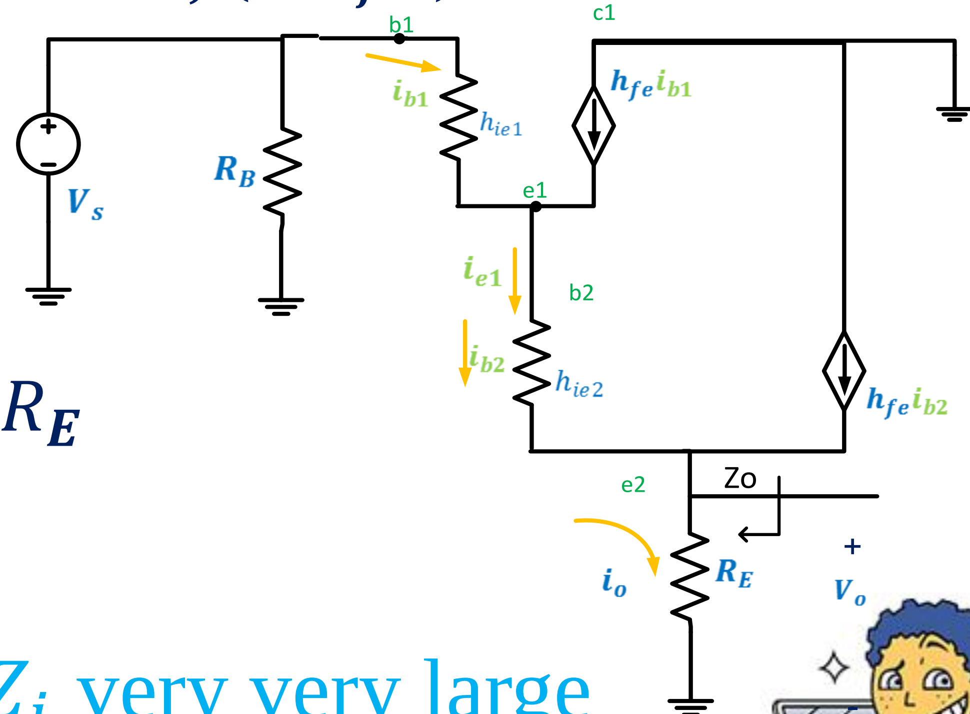
$$Z_i = h_{ie1} + (h_{ie2} + R_E\ (1+h_{fe2})\ )(1+h_{fe1})$$



Darlington compound configuration

$$A_v = \frac{R_E(1+h_{fe2})\,(1+h_{fe1})}{h_{ie1}+\left(R_E\ (1+h_{fe2})+h_{ie2}\right)(1+h_{fe1})} < 1$$

To find Z_O , set $V_S = 0$



$$Z_O = \left(\frac{\frac{h_{ie1}}{1+h_{fe1}}+h_{ie2}}{1+h_{fe2}}\right) || R_E$$

$\therefore A_i > 1$

$A_v < 1$

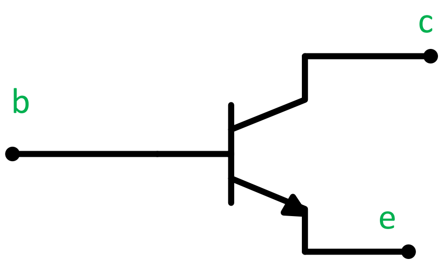
Z_i very very large

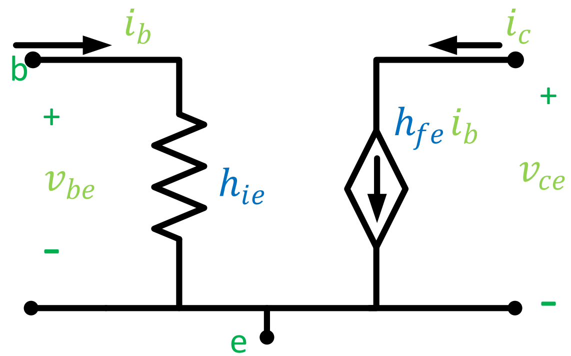
Z_O very very small

modified buffer

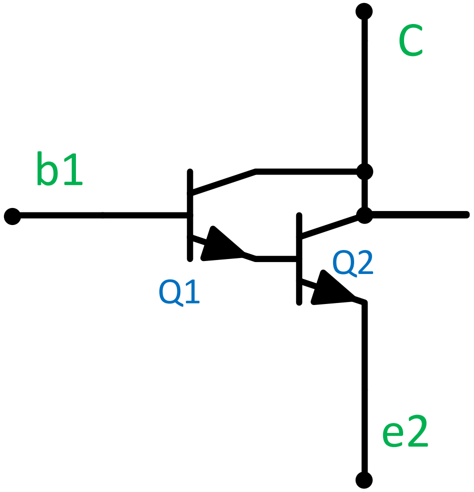
Darlington compound configuration

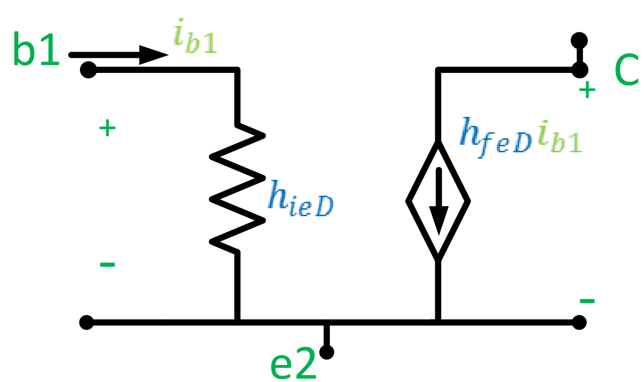
Ac small signal equivalent circuit of the BJT



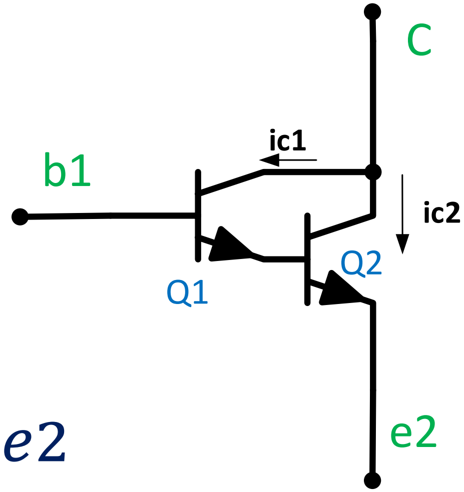


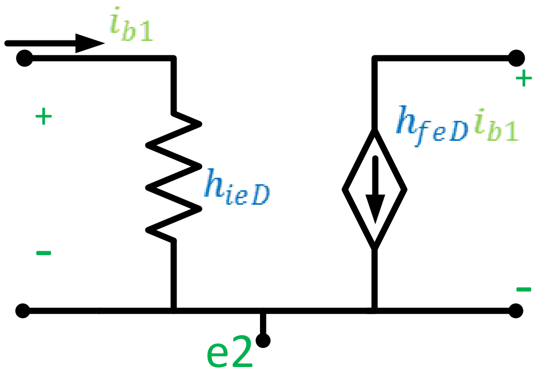
Ac small signal equivalent circuit of the Darlington





Darlington compound configuration





$$h_{ieD} = 2\ h_{ie1}$$

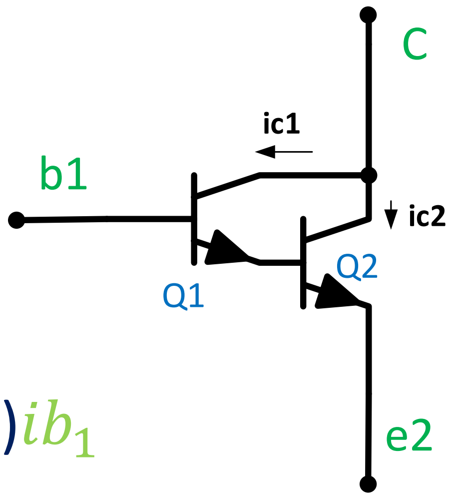
$$h_{feD} = h_{fe1} . h_{fe2}$$

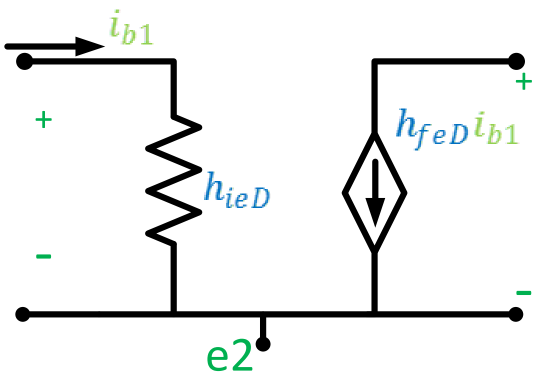
$$h_{feD} = \frac{i_c}{ib_1}$$

$h_{ieD} = Z_i$ with R_E=0

Darlington compound configuration

$$h_{feD}=\frac{i_c}{ib_1}$$





$i_c = i_{c1} + i_{c2}$

$i_c = h_{fe1}\, ib_1 + h_{fe2} ib_2$

$i_c = h_{fe1} ib_1 + h_{fe2}\, \mathrm{ie}_1$

$i_c = h_{fe1} ib_1 + h_{fe2}(1 + h_{fe1}) ib_1$

$i_c = (h_{fe1} + h_{fe2} + h_{fe2} h_{fe1}) ib_1$

$h_{feD} = h_{fe1} + h_{fe2} + h_{fe2} h_{fe1}$

$h_{feD} \approx h_{fe2} h_{fe1}$

Darlington compound configuration

$$h_{ieD} = Z_i \Big|_{R_E=0}$$

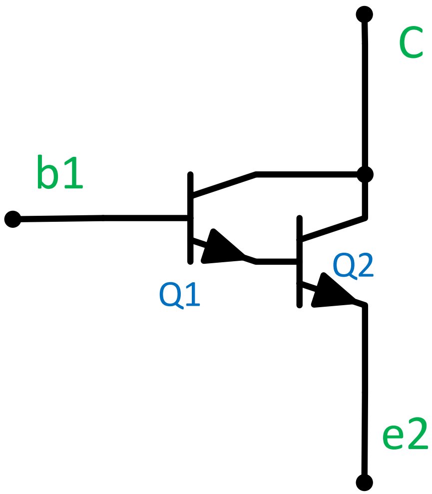
- $Z_i = h_{ie1} + (R_{\boldsymbol{E}}\,(1+h_{fe2})+h_{ie2})(1+h_{fe1})$

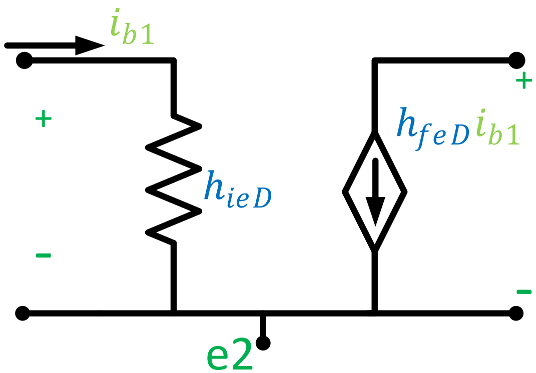
$\therefore\ h_{ieD} = h_{ie1} + (1+h_{fe1})\ h_{ie2}$

$$= h_{ie1} \quad + (1+h_{fe1})\,\frac{(1+h_{fe2})V_T}{I_{E2}}$$

$$= h_{ie1} \quad + (1+h_{fe1})\,\frac{(1+h_{fe2})V_T}{(1+h_{fe2})I_{E1}}$$

Darlington compound configuration



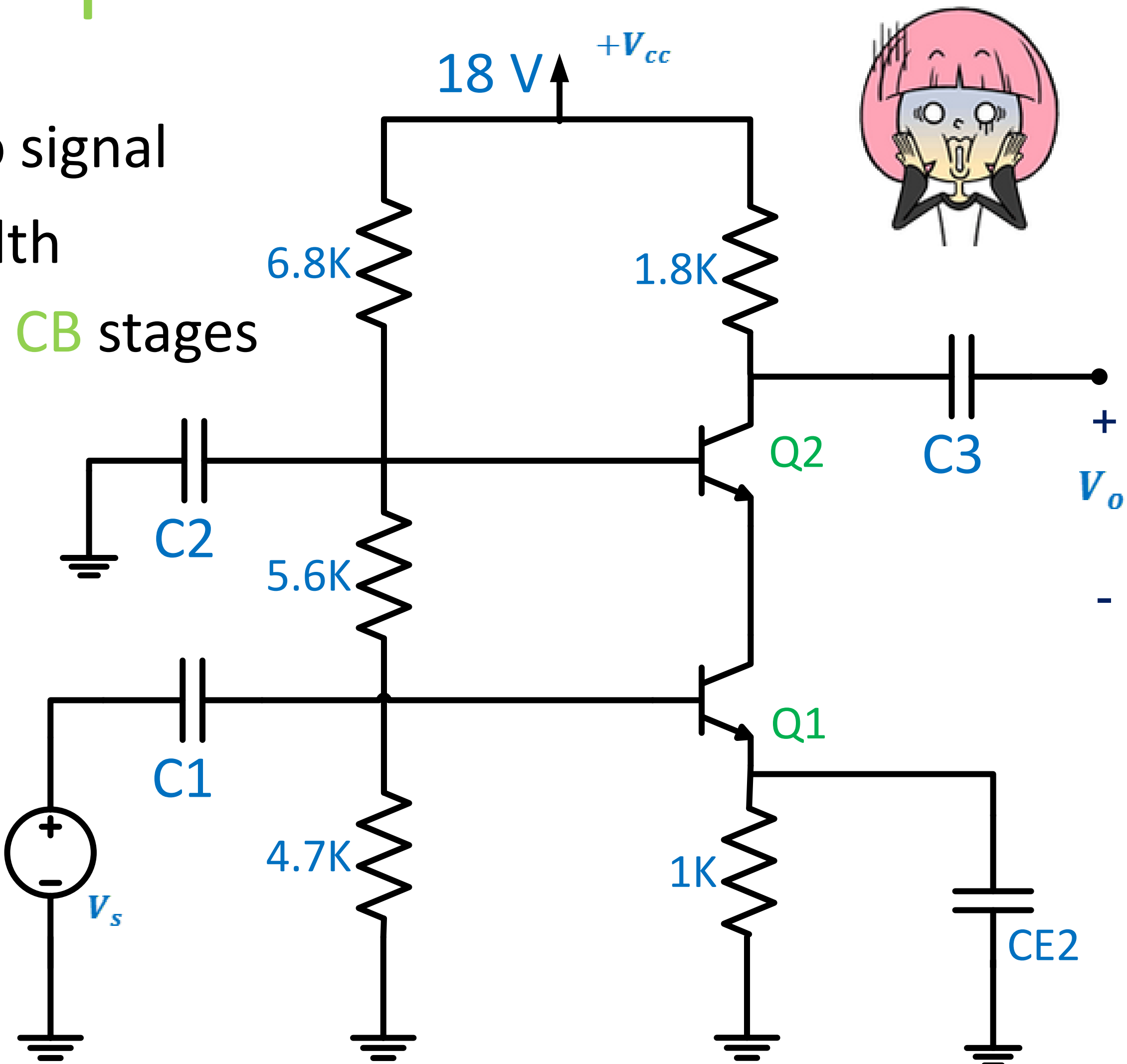


$$\therefore\ h_{ieD} = \ = h_{ie1} + \frac{(1+h_{fe1})V_T}{I_{E1}}$$

$$h_{ieD} = h_{ie1} + h_{ie1}$$
$$= 2h_{ie1}$$

Cascode Amplifier

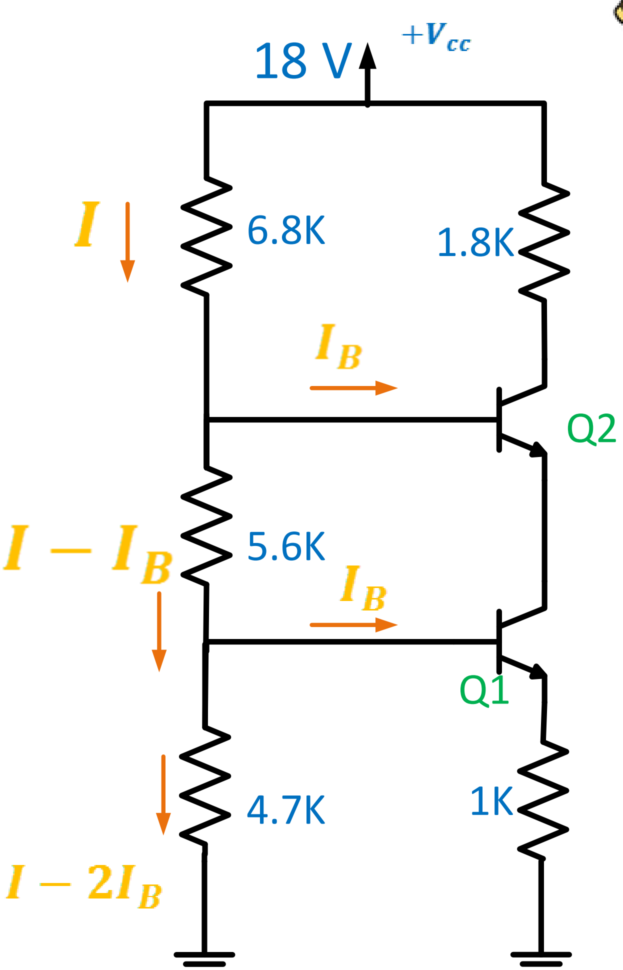
- Used to amplify video signal
- It has a wide bandwidth
- It consists of a CE and CB stages or CS and CG stages .

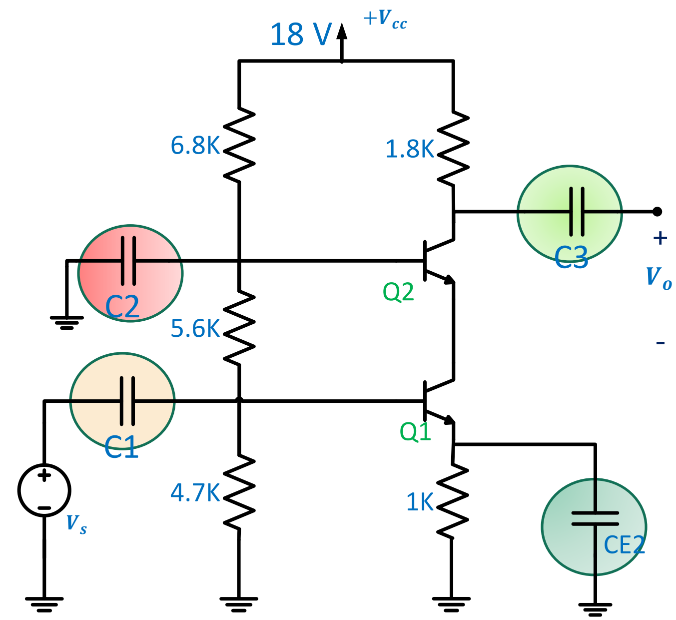


$\beta 1 = \beta 2 = 100$

Cascode Amplifier

DC Analysis :





$\beta 1 = \beta 2 = 100$

Open Circuit!

IC1 = IE2 ≈ IC2

Since ß1 = ß2

IB1 = IB2 = IB

Cascode Amplifier

DC Analysis :

$I_{C1} = I_{E2} = I_{C2}$

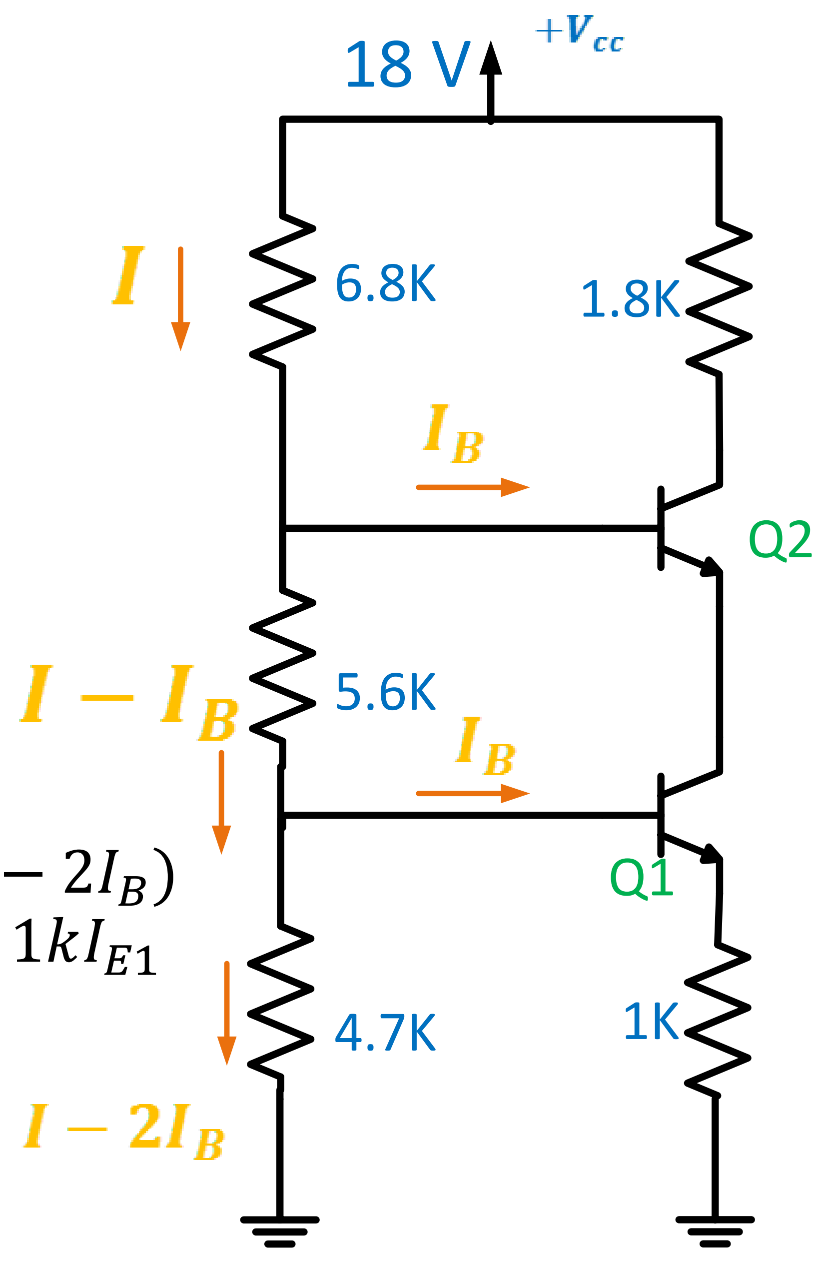
And since β1=β2

$I_{B1} = I_{B2} = I_B$

$18 = 6.8\text{k}\, I + 5.6k(I - I_B) + 4.7k(I - 2I_B)$

$18 = 6.8\text{k}\, I + 5.6k(I - I_B) + V_{BE1} + 1kI_{E1}$

Solving for $I_E = 4mA$



Cascode Amplifier

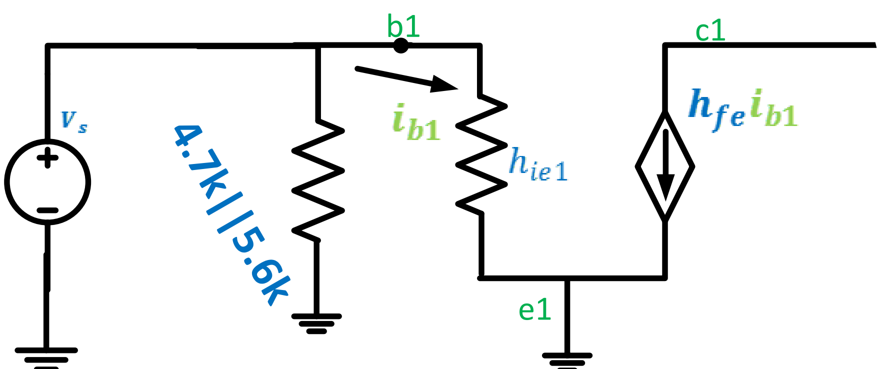
Ac small signal analysis

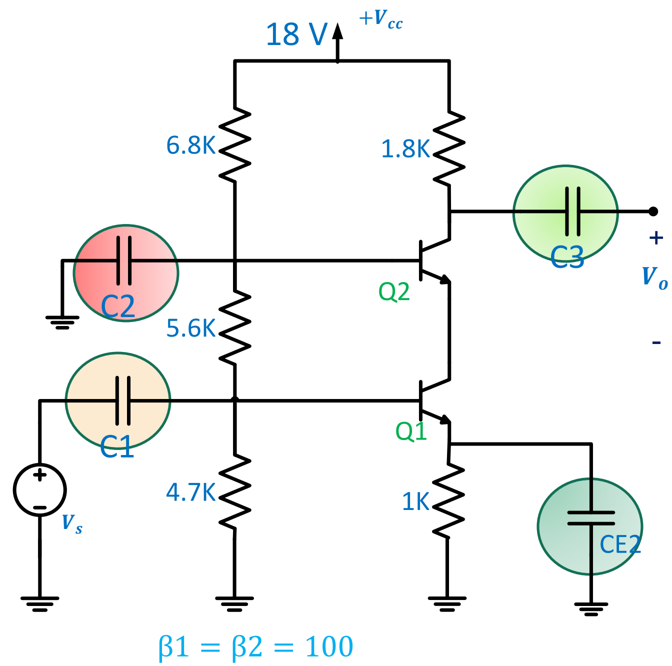
V_O= $-h_{fb}ie_2$ (1.8K)

ie_2= $h_{fe1}ib_1$

ib_1= $\frac{V_S}{h_{ie1}}$

$\therefore \quad A_v$= -294





Short Circuit!