02.03.2022

Analysis of Common-Emitter Amplifier

$I_{C,sat} = \frac{V_{CC}}{R_C} = \frac{10V}{3.6k\Omega} = 2.76\,mA$

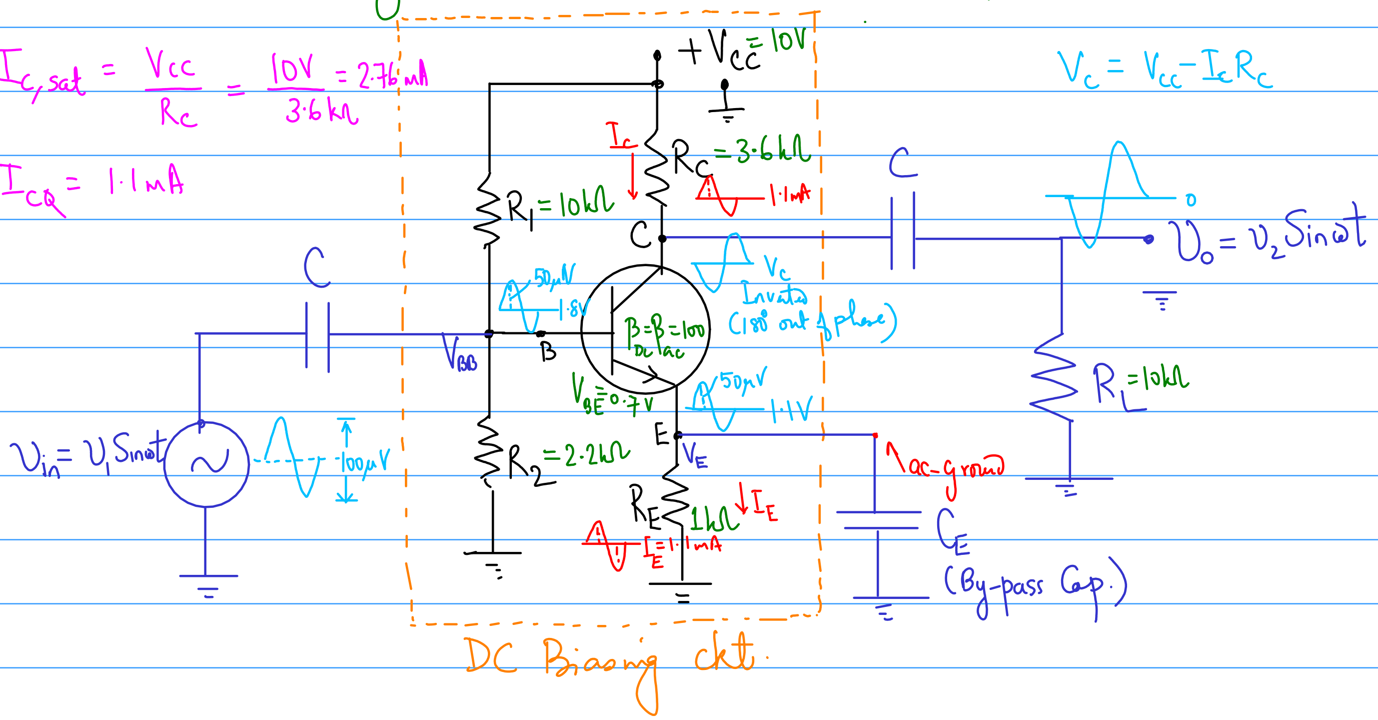
$I_{CQ} = 1.1\,mA$

$\beta_{DC} = \frac{I_C}{I_B}$

$\beta_{ac} = \frac{i_c}{i_b}$

$\beta_{DC} \approx \beta_{ac}$

$V_C = V_{CC} - I_C R_C$



Recap:

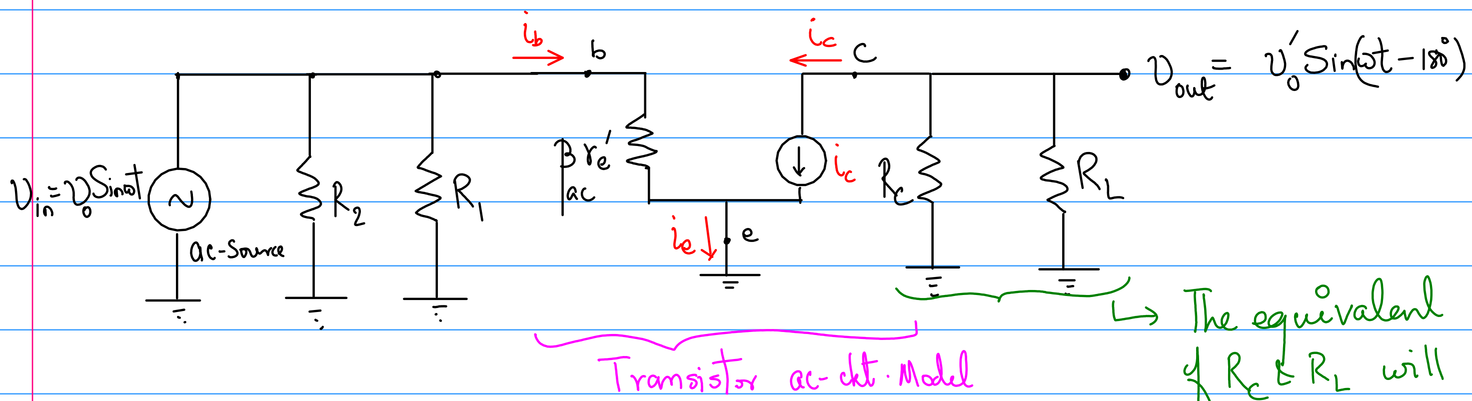
1) For DC Analysis

- All capacitors are OPEN.
- Value of the resistors R_1, R_2, R_E & R_C are selected such that the operating point (Q-point) lies nearly at the middle of load line. ($V_{CEQ} = 0.5\,V_{CC}$).

2) For AC Analysis

- All capacitors are SHORT.
- All dc-sources are also SHORT.
- Use ac-equivalent model of the transistor. (either T-model or π-model)

ac-equivalent ckt. of the CE amplifier:



↳ The equivalent of R_c & R_L will appear as a load resistance

$r_c = R_c \| R_L$

$$\boxed{A_v = \frac{r_c}{r_e'}}$$

Estimation of voltage-gain:

$$r_c = 3.6\,k\Omega \,\|\, 10\,k\Omega = \left[\frac{3.6 \times 10}{3.6 + 10}\right] k\Omega$$

$$r_c = \frac{36}{13.6}\,k\Omega = 2.65\,k\Omega$$

Also, $$r_e' = \frac{25\,mV}{1.1\,mA} = 22.7\,\Omega$$

Therefore, $$A_v = \frac{r_c}{r_e'} = \frac{2.65\,k\Omega}{22.7\,\Omega} = \frac{2650}{22.7} \approx 116$$

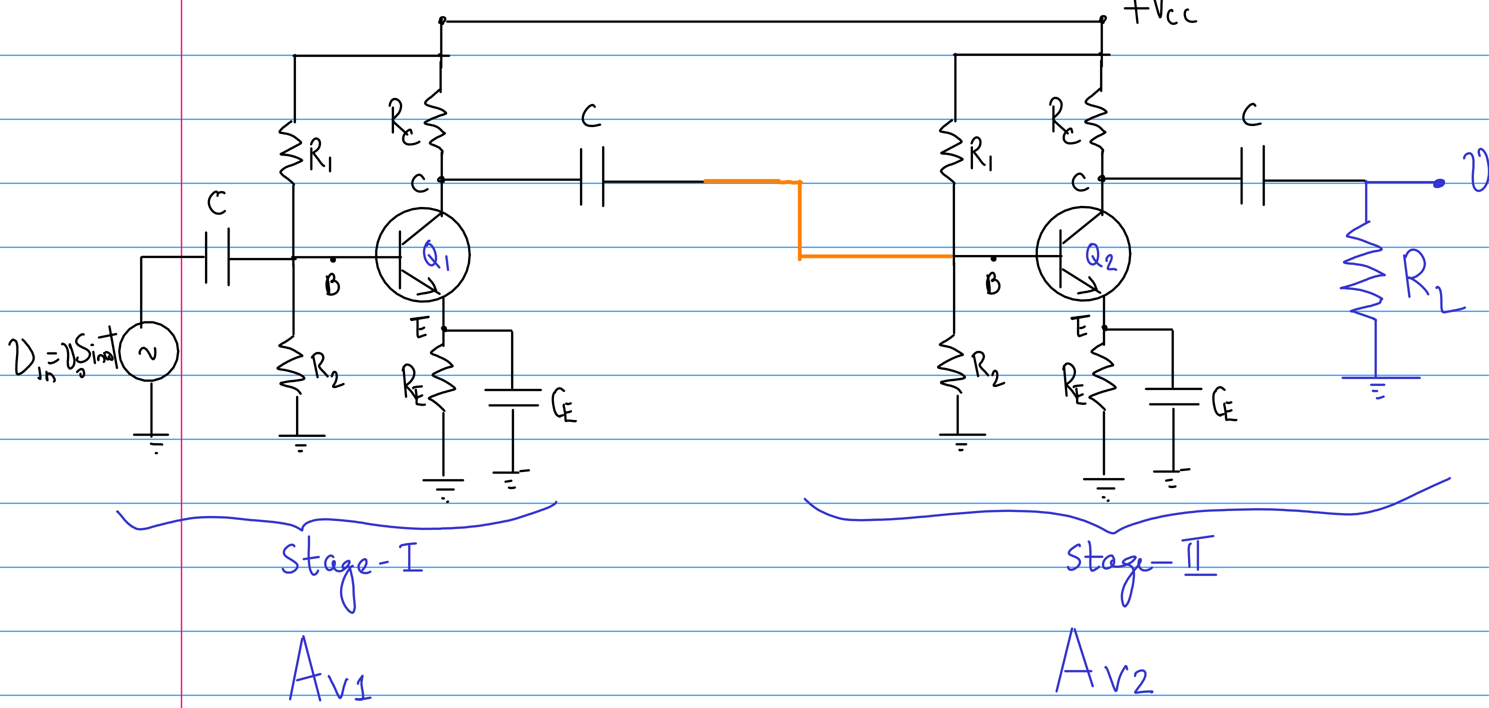
$$\boxed{A_v = 116}$$

Let's consider, input ac-signal of amplitude $v_o(p\text{-}p) = 100\mu V$

then, $v_o'(p\text{-}p) = A_v \cdot 100\mu V = 116 \times 100\mu V$

$$\boxed{v_o'(p\text{-}p) = 11.6\ mV}$$

Multi-stage (eg. Two-stage) direct coupled CE Amplifier:



Overall voltage gain $A_v = A_{v_1} \cdot A_{v_2}$

Similarly, if there 'n' no. of stages, we have

$$A_v = A_{v_1} \cdot A_{v_2} \cdot A_{v_3} \cdots\cdots A_{v_n}$$

For a given input signal of amp. $= 100\,\mu V$ (p-p)

Output of the two-stage amp $= A_V \cdot 100\,\mu V$ (p-p)

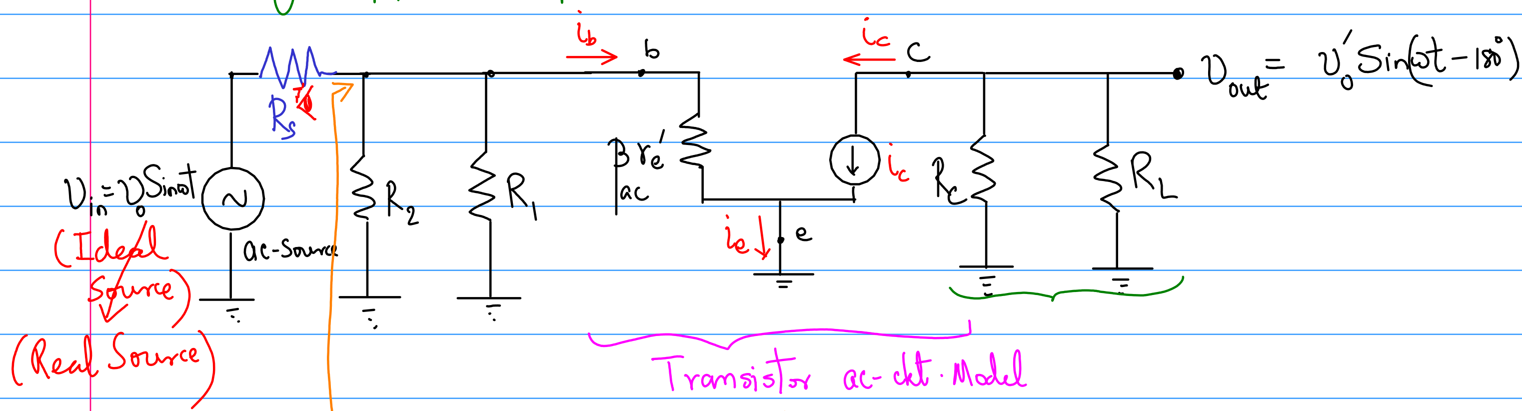
$= A_{V_1} \cdot A_{V_2} \cdot 100\,\mu V$ (p-p)

$= \underbrace{(116)}_{\text{calculated value}} \cdot \underbrace{(100)}_{\text{assuming}} \cdot 100\,\mu V$ (p-p)

$= 1.16\ V$ (p-p)

$\Rightarrow$ there is an enhancement (amplification) of 4-orders of magnitude.

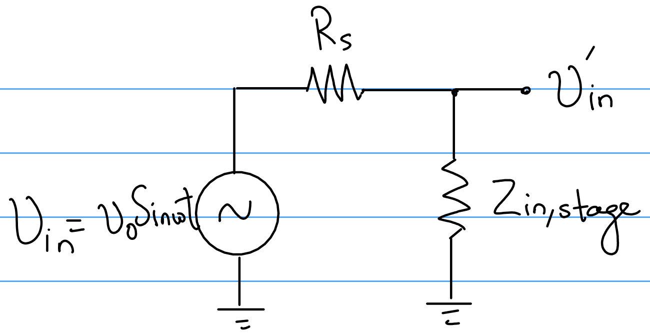
Loading effect of Input ac-source :



$Z_{in\text{-}stage} = R_1 \| R_2 \| \beta_{ac} r_e'$

if $Z_{in\text{-}stage} \geq 100\, R_s$ then the input ac-source is stiff.

But in case $Z_{in\text{-}stage} \sim R_s$ or Lower



If the stiff condⁿ is meeting then $v_{in}' = v_{in} = v_0 \sin\omega t$

In case the stiff condⁿ is not meeting then,

$$v_{in}' = \left[\frac{Z_{in,stage}}{Z_{in,stage} + R_s} \right] \cdot v_{in}$$