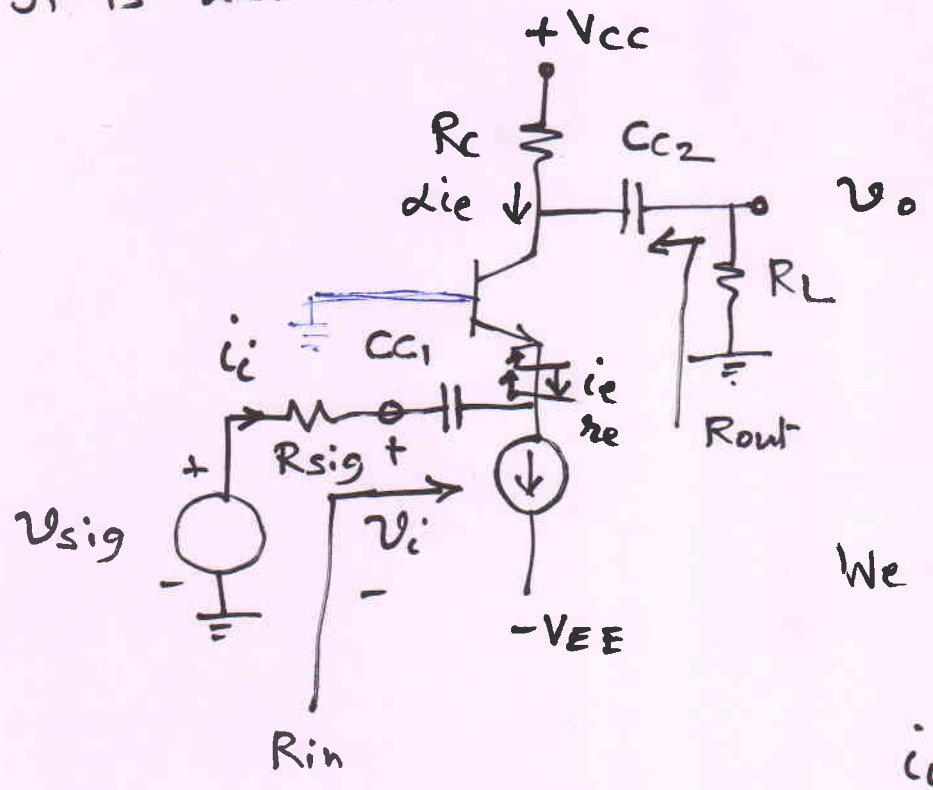
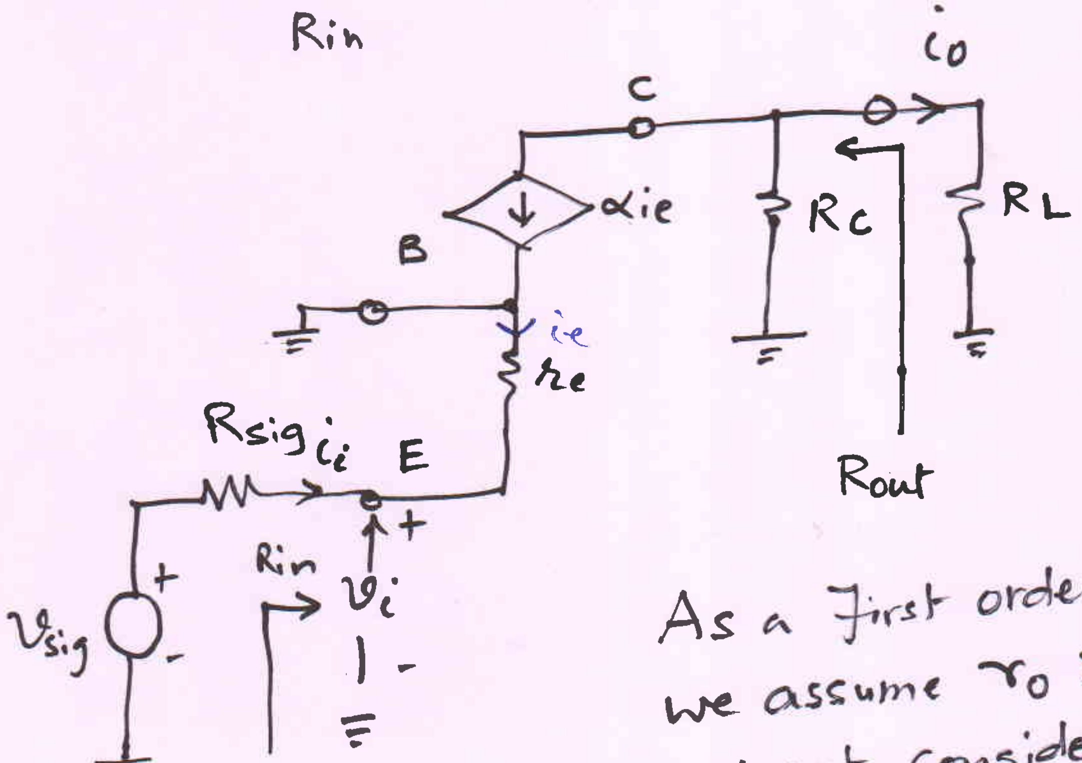
COMMON BASE AMPLIFIER (CB) CONFIGURATION

It is configured by feeding input to emitter, grounding the base and taking output from collector. It is also called as "Grounded Base Amplifier".



We use T-model here



As a first order simplification we assume $r_o >> R_C$ or R_L, and not considered.

by inspection, input resistance R_{in} is

$$R_{in} = r_e$$

This is so because base is grounded & we are looking in from emitter. $r_e \approx 25\,\Omega$

output voltage $v_o = -\alpha i_e (R_C \| R_L)$

$$i_e = -\frac{v_i}{r_e}$$

(Normally v_i is considered as + at base and -ve at emitter. Since base is grounded as per our convention voltage at emitter will be more negative than base which is at 0V. Hence - sign or polarity).

so voltage Gain $A_v \equiv \dfrac{v_o}{v_i} = \dfrac{\alpha}{r_e}(R_C \| R_L)$

$$A_v = g_m (R_C \| R_L)$$

Effective resistance between Collector & Ground.

Note that A_v has +ve sign which means that there is NO Phase Shift between emitter and collector voltage.

Ideal or Open Circuit Voltage Gain A_{vo} (when $R_L = \infty$)

$$A_{vo} = g_m \cdot R_C$$

These results are similar to CE configuration.

(12) $R_{out} = R_C$ (or $R_C \| r_o$ but right now r_o is not included or considered as ∞)

which is again .

The short circuit current gain A_{is} will be

$$A_{is} = \left.\frac{i_o}{i_i}\right|_{\text{load shorted to 0.}}$$

$$= \frac{-\alpha i_e}{i_i} = \frac{-\alpha i_e}{-i_e} = \alpha$$

∴ Current GAIN IS NEARLY UNITY.

Note that in CE case, it is about β.

Note that the Overall Voltage Gain of the CB amplifier is much worse than that of CE because of lower input resistance:

Overall volt. Gain $G_v = \dfrac{v_o}{v_{sig}}$

$$= \frac{v_i}{v_{sig}} \cdot \frac{v_o}{v_i}$$

$$= \frac{r_e}{R_{sig} + r_e}\left(g_m(R_C \| R_L)\right)$$

$$= \frac{\alpha(R_C \| R_L)}{R_{sig} + r_e}$$

Thus the overall voltage Gain is a ratio of "total resistance in collector" divided by "total resistance in emitter" circuit. It is independent of β.

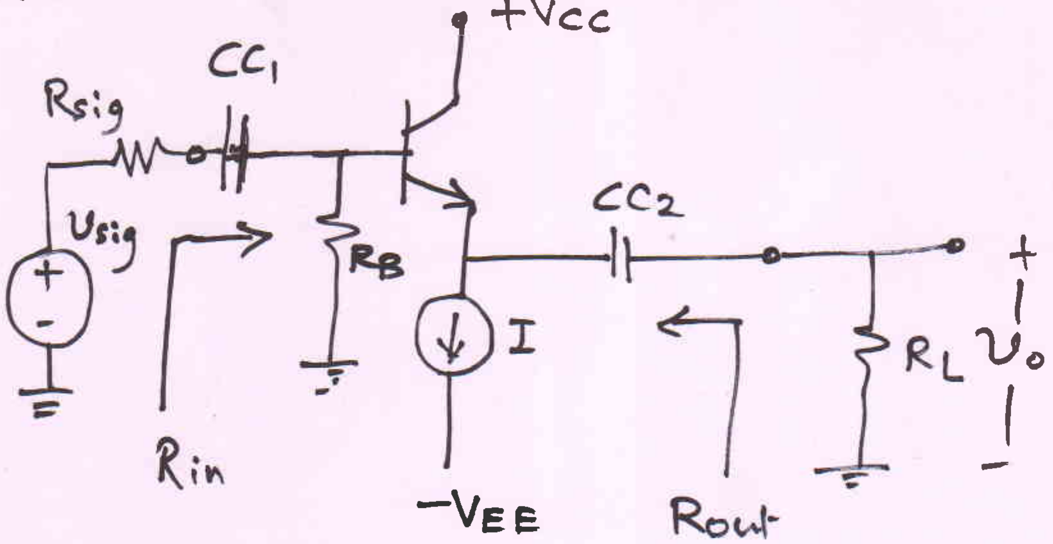
However, if $R_{sig} \approx (R_C \| R_L)$ then voltage gain will be very small or nearly UNITY.

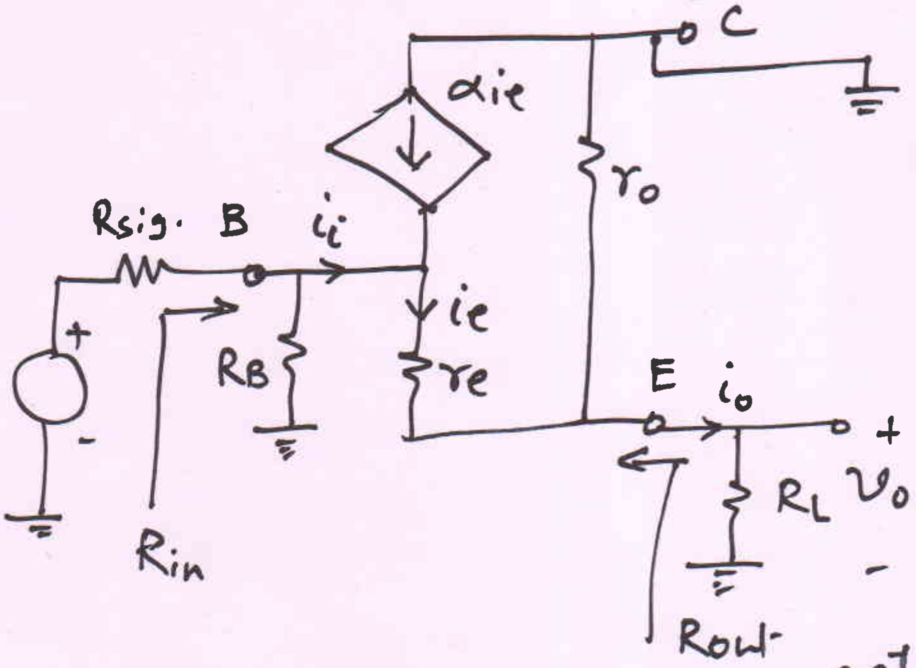
Summary: CB amplifier has a very low input resistance, a unity current gain, a high output resistance ($\approx R_C$). It is used only with transmission lines of low impedance which must be "terminated" with equal "characteristic impedance" of same value. So a 50 Ω cable carrying signal will be suitably terminated by a CB amplifier of 25 Ω input resistance as compared to a CE amplifier of 2500 Ω resistance.

CB amplifier accepts input at low input impedance and forces same current through higher output impedance & is called as Unity Gain Current Amplifier or Current Buffer.

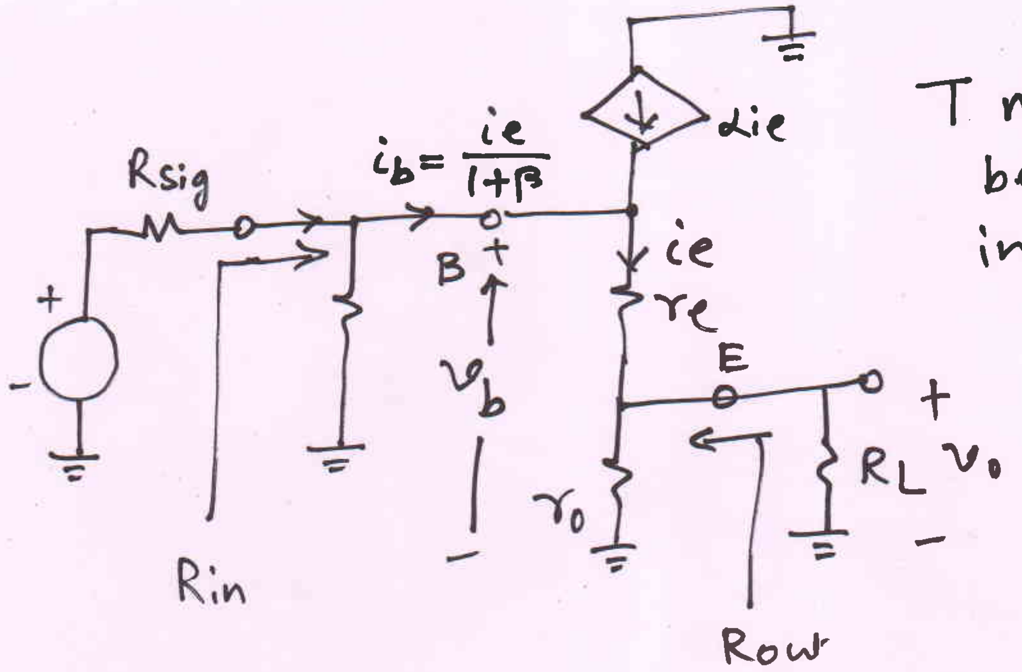
The Common Collector (CC) or Emitter Followers Configuration

Here the collector is at signal ground, input is given at base & output is taken at emitter.
$\because$ Collector is going to be grounded there is no place or need for R_C.





Note that r_o and R_L are actually in parallel.



T model chosen because R_L is in series with r_e. ~~Re~~.

Unlike CE & CB, the CC or EF circuit is not unilateral but it is BILATERAL. i.e. the change in R_L or output side conditions DO AFFECT the input resistance & thus input current. Let us see how...

Using resistance reflection rule, all resistance between emitter and ground $(r_e + (r_o \| R_L))$ will be reflected to base multiplied by $(1+\beta)$.

$$R_{ib} = (\beta+1)\left[r_e + (r_o \| R_L)\right]$$

$\because \beta$ is quite large, even a moderate value of R_L gets magnified & R_{ib} is quite large.

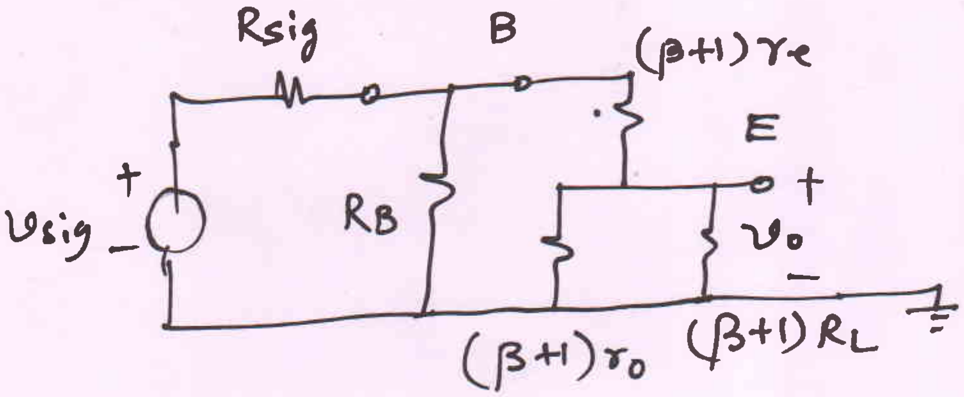
Total input resistance seen by signal source

$$R_{in} = R_{ib} \| R_B$$

For $r_e = 25\Omega$, $R_L = 1K$, $R_B = 100K$, $r_o = \infty$

$$R_{in} = 101\left[25 + 1000\right] \approx \underline{\underline{101K}}$$ Quite Large

The emitter resistors after reflecting to base get multiplied by $(1+\beta)$ and equiv. ckt looks like —



Overall Voltage Gain G_v

$$G_v = \left(\frac{R_B}{R_{sig}+R_B}\right) \frac{(\beta+1)(r_o \parallel R_L)}{(R_{sig} \parallel R_B) + (\beta+1)\left[r_e + (r_o \parallel R_L)\right]}$$

Note there are two potential dividers here

First : emitter voltage is a fraction of Base voltage

second : Base voltage is a fraction of Rsig & $(R_B \parallel R_{ib})$.

G_v is less than unity but close to unity.

Thus voltage at emitter follows voltage signal closely & amplifier is called Emitter Follower.

When $R_{sig}/(1+\beta) << R_L$ or $(\beta+1)R_L >> R_{sig}$

then $G_v \approx 1$.

If $R_L = \infty$ i.e. Open circuited $G_{vo} \approx 1$.

To measure output resistance R_{out}, make $v_{sig} = 0$ & look into emitter terminal (17)

$$R_{out} = r_o \parallel \left(r_e + \frac{R_{sig} \parallel R_B}{\beta + 1} \right)$$

The second term is base resistors reflected to emitter side (divided by $(1+\beta)$).

This shows that output resistance is a function of input side resistors.

If r_o is quite high then

$$R_{out} = r_e + \left(\frac{R_{sig} \parallel R_B}{\beta + 1} \right)$$

If $\beta = 100$, $R_{sig} = 1k$, $R_B = 100k$, $r_e = 25\,\Omega$

then $R_{out} = 25 + \frac{1k}{101} \approx 35\,\Omega$

or very small value.

Summary, CC amplifier has HIGH input impedance $(50k \to 100k)$, Low output impedance $(\approx 50\Omega)$, Unity Voltage Gain, Zero phase shift and $1+\beta$ current gain. Since a very small fraction of applied signal appears between emitter and base, it permits a very large input signal swing without distortion.