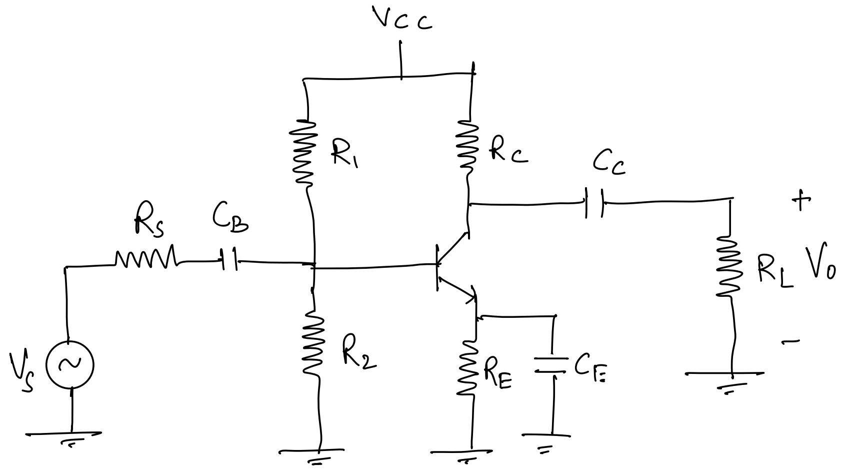
AC Analysis of CE, CB, CC Configuration:

1. Common Emitter Amplifier with bypass Capacitor:



C_B : Blocking Capacitor : To fix Q-point i.e it provides DC isolation to biasing circuit. [To block DC]

C_C : Coupling Capacitor : To fix Q-point i.e it provides DC isolation to biasing circuit. [To block DC]

C_E : Emitter bypass capacitor: To prevent the fall in Voltage gain at midband.

C_B, C_C, C_E : Large Capacitance [µF Range]

- C_B, C_C are connected to provide DC Isolation to the biasing circuit so that external elements i.e R_L, V_S and R_S does not disturb the operating point.

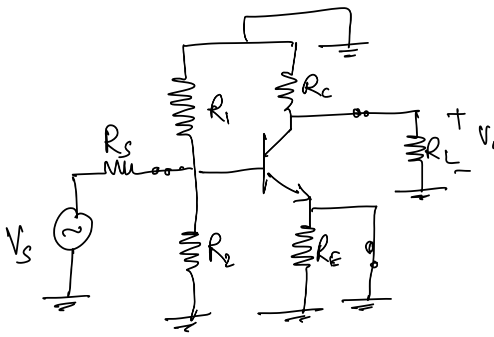
Procedure to Analyse Amplifier:

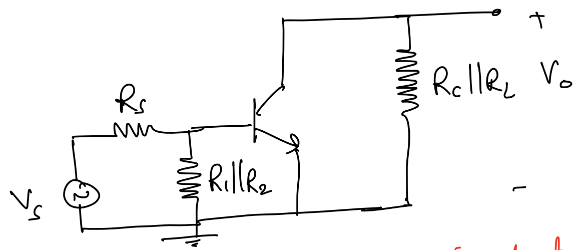
Step 1: Identify the BJT Configuration in given circuit.

Step 2: Draw medium frequency AC equivalent circuit by replacing

1. Large Capr with s/c.
2. Small capr with o/c.

3. By connecting Vcc node to ground (In AC Analysis, DC supply Vcc is deactivated)

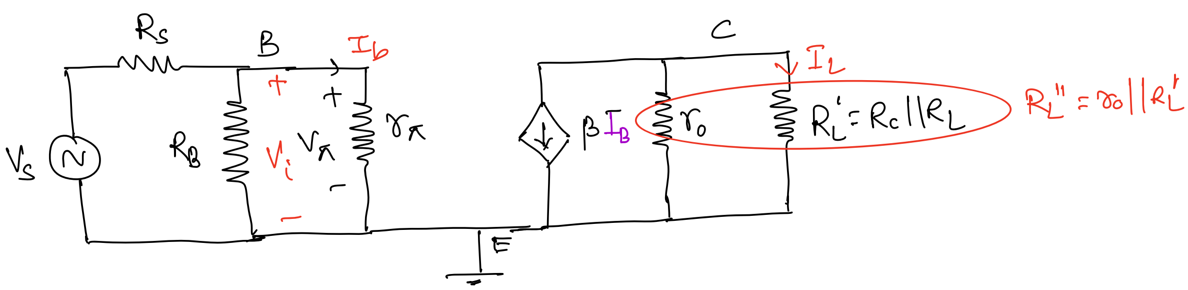




Medium frequency AC equivalent circuit
[$R_B = R_1 || R_2$, $R_L' = R_c || R_L$]

Step 3: Replace BJT with small signal hybrid π equivalent model and calculate required values.

1. Common Emitter amplifier with bypass capacitor:



1. Current Gain (A_I):

$$A_I = \frac{I_L}{I_B}$$

$$A_I = \frac{-\beta I_B \times r_o}{I_B (r_o + R_L')} = \frac{-\beta r_o}{r_o\left(1 + \frac{R_L'}{r_o}\right)}$$

$$A_I = \frac{-\beta}{1 + \frac{R_L'}{r_o}}$$

If $\frac{R_L'}{r_o} \ll 1$

$$\boxed{A_I = -\beta}$$

Indicate load current is opposite to collector current.

2. Input Resistance (R_i):

$$R_i = \frac{V_i}{I_b}$$

$$R_i = \frac{r_\pi I_b}{I_b}$$

$$\boxed{R_i = r_\pi}$$

3. Voltage Gain (A_v):

$$A_v = \frac{V_o}{V_i}$$

$$A_v = \frac{-\beta I_b R_L''}{I_b r_\pi}$$

$$A_v = -\frac{\beta}{r_\pi} R_L''$$

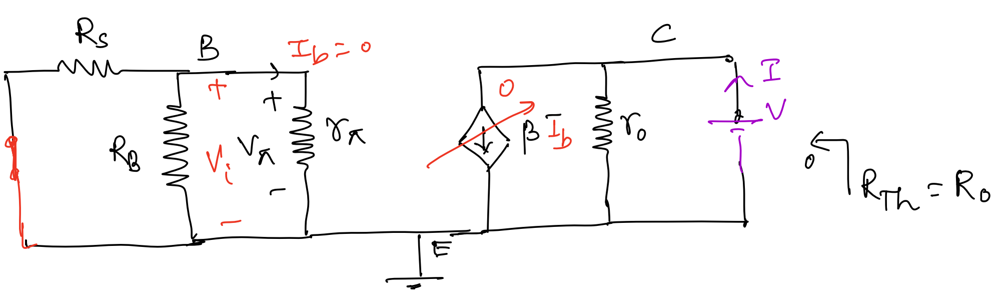
$$\boxed{A_v = -g_m R_L''}$$

If r_o is neglected then,

$$\boxed{A_v = -g_m R_L'}$$

$-$Ve Sign indicates phase shift of 180° between V_i and V_o.

4. Output Resistance (R_o):



$$\boxed{R_o = R_{Th} = \frac{V}{I} = r_o}$$

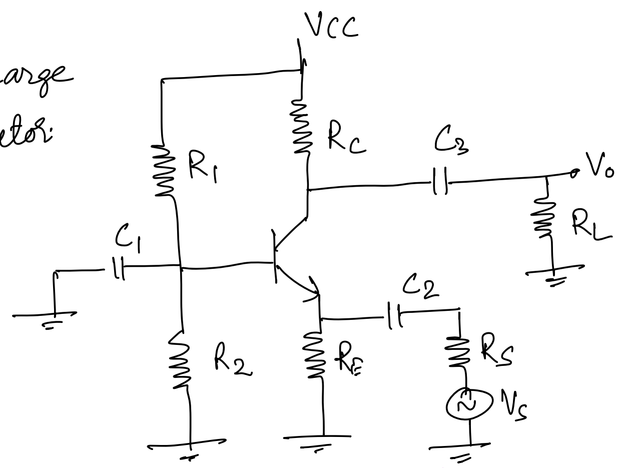
2. Common Base amplifier :

C_1, C_2, C_3 are large Capacitor.

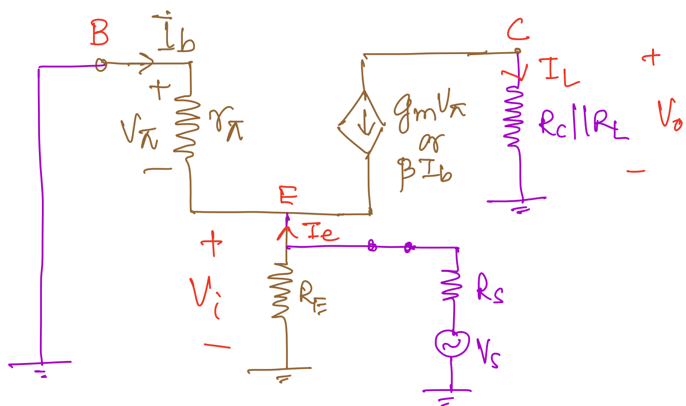
i/p Node : Emitter

O/P Node : Collector

Common Node : Base



Medium frequency AC Equivalent circuit



1. Current Gain (A_I) :

$$A_I = \frac{I_L}{I_e}$$

$$I_L = -\beta I_b$$

$$I_e = -\left(I_b + \beta I_b\right) = -(1+\beta) I_b$$

$$A_I = \frac{I_L}{I_e} = \frac{-\beta I_b}{-(1+\beta) I_b} = \frac{\beta}{1+\beta} \simeq 1$$

CB Ampr has unity Current Gain.

2. Input Resistance (R_i) :

$$R_i = \frac{V_i}{I_e}$$

Apply KVL in loop (1) ;

$$V_i = -V_\pi = -I_b r_\pi$$

$$I_e = -(1+\beta) I_b$$

$$R_i = \frac{V_i}{I_e} = \frac{-I_b r_\pi}{-(1+\beta) I_b} = \frac{r_\pi}{1+\beta}$$

3. Voltage Gain (A_V) :

$$A_V = \frac{V_o}{V_i} = \frac{-\beta I_b R_L'}{-V_\pi}$$

$R_L' = R_C || R_L$

$$A_V = \frac{-\beta \cancel{I_b} R_L'}{\cancel{I_b} r_\pi}$$

$$A_V = -\frac{\beta}{r_\pi} R_L' = -g_m R_L'$$

$$\boxed{A_V = -g_m R_L'}$$

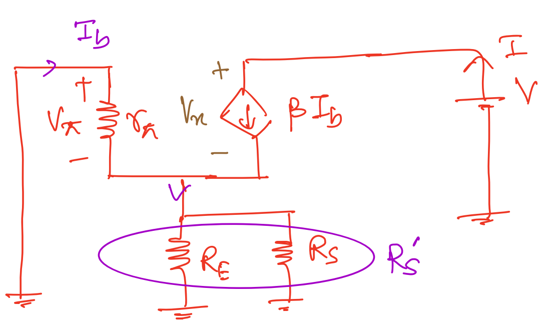
CB Amplifier has large voltage gain.

4. Output Resistance (R_o) :

$$R_o = \frac{V}{I}$$

$I_b = 0, \quad I = 0$

$$R_o = \frac{V}{0} = \infty$$

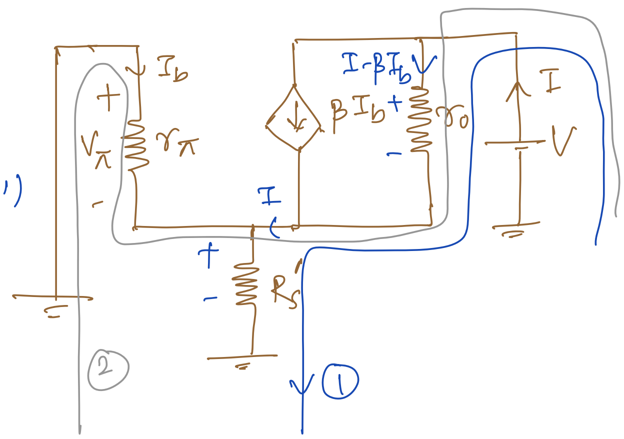


O/P Resistance is large in CB Ampr.

Apply KVL in loop(1);

$$V - (I - \beta I_b) r_0 - (I + I_b) R_s' = 0$$

$$V = I(r_0 + R_s') + I_b(R_s' - \beta r_0) \quad \text{—— (1)}$$



Apply KVL in loop(2);

$$V - (I - \beta I_b) r_0 + I_b r_\pi = 0$$

$$V = I r_0 + I_b(r_\pi + \beta r_0)$$

$$I = \frac{V - I_b(r_\pi + \beta r_0)}{r_0} \quad \text{—— (2)}$$

from eqn(1) & eqn(2);

$$V = \left[\frac{V}{r_0} - \frac{I_b}{r_0}(r_\pi + \beta r_0)\right](r_0 + R_s') + I_b(R_s' - \beta r_0)$$

$$V = V\left(1 + \frac{R_s'}{r_0}\right) - I_b\left(1 + \frac{R_s'}{r_0}\right)(r_\pi + \beta r_0) + I_b(R_s' - \beta r_0)$$

$$-V\frac{R_s'}{r_0} = -I_b\left[\left(1 + \frac{R_s'}{r_0}\right)(r_\pi + \beta r_0) - (R_s' - \beta r_0)\right]$$

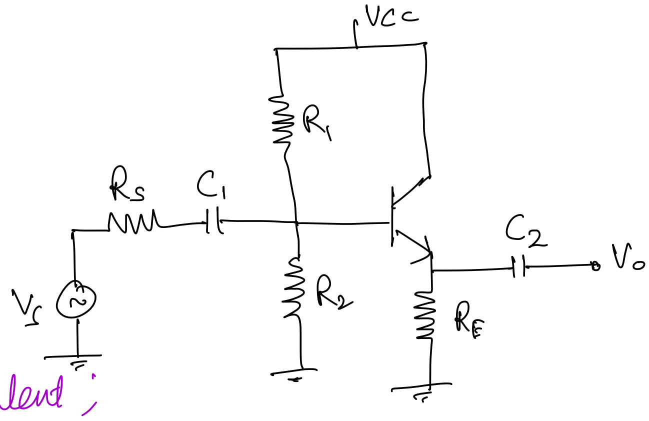
$(1+\beta r_0)$

3. Common Collector Amplifier:

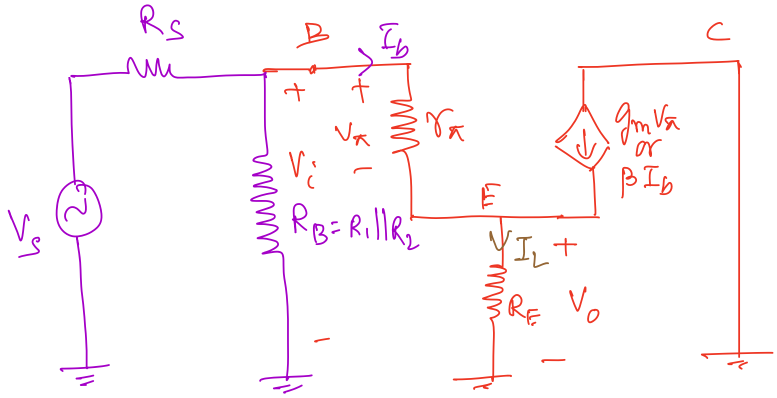
i/p Node: Base

o/p Node: Emitter

Common Node: Collector



Medium frequency AC equivalent;



1. Current Gain (A_I):

$$A_I = \frac{I_L}{I_b} = \frac{(1+\beta) I_b}{I_b} = 1+\beta$$

$$\boxed{A_I = 1+\beta}$$

2. Input Impedance (R_i):

$$R_i = \frac{V_i}{I_b} = \frac{I_b r_\pi + (1+\beta) I_b R_E}{I_b}$$

$$\boxed{R_i = r_\pi + (1+\beta) R_E}$$

3. Voltage Gain (A_v):

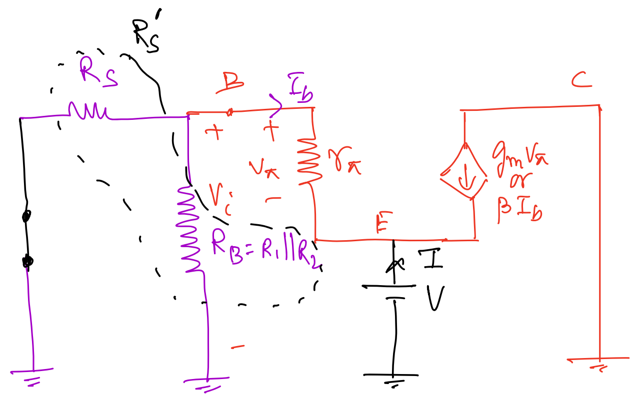
$$A_v = \frac{V_o}{V_i} = \frac{(1+\beta) I_b R_E}{I_b r_\pi + (1+\beta) I_b R_E}$$

$$\boxed{A_v = \frac{(1+\beta) R_E}{r_\pi + (1+\beta) R_E}}$$

4. Output Impedance (R_o):

$$R_o = \frac{V}{I}$$

$$\boxed{R_o = \frac{R_s' + r_\pi}{1+\beta}}$$



$$I = -(1+\beta) I_b$$

Apply KVL in loop (1);

$$+V + I_b r_\pi + I_b R_s' = 0$$

$$V = -I_b (r_\pi + R_s')$$

$$V = \frac{I}{1+\beta} (r_\pi + R_s')$$

$$\boxed{R_o = \frac{V}{I} = \frac{r_\pi + R_s'}{1+\beta}}$$