Low frequency analysis of BJT:

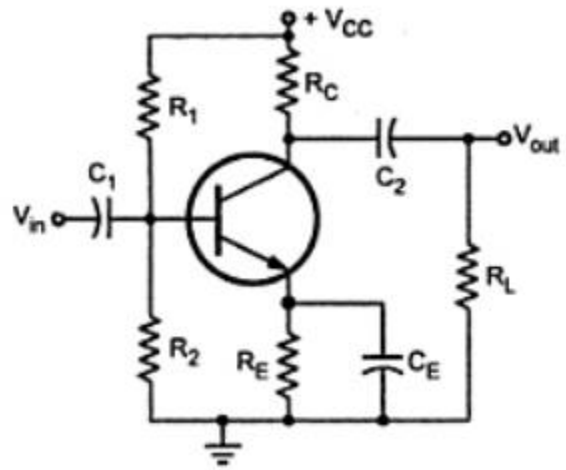

Figure 4.3.1 Typical RC coupled Common Emitter Amplifier

Diagram Source Brain Kart

From above figure 4.3.1, it has three RC networks that affect its gain as the frequency is reduces below midrange. These are RC network formed by the input coupling capacitor C_1 and input impedance of the amplifier. RC network formed by the output coupling capacitor C_2, resistance looking in at the collector and load resistance. RC network formed by the emitter bypass capacitor C_E and resistance looking in at the emitter.

Input RC network:

The following figure 4.3.2 shows the input RC network formed by C_1 and the input impedance of the amplifier.

The resistance value is $R_{in} = R_1 \parallel R_2 \parallel R_{in}(base)$

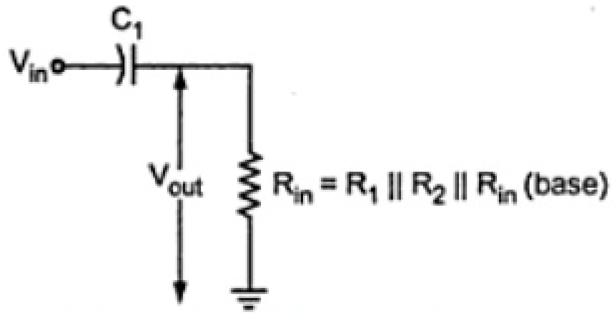

Figure 4.3.2 Voltage Divider Rule

Diagram Source Brain Kart

Applying voltage divider rule,

$$V_{out} = \left(\frac{R_{in}}{\sqrt{R_{in}{}^2 + X_{C1}{}^2}} \right) V_{in}$$

A critical point in the amplifier response is generally accepted to occur when the output voltage is 70.7 % of the input. At critical point,

$$\frac{R_{in}}{\sqrt{R_{in}{}^2 + X_{C1}{}^2}} = 0.707 = \frac{1}{\sqrt{2}}$$

At this condition, $R_{in} = X_{c1}$. Overall gain is reduced due to attenuation provided by the input RC network. The reduction in overall gain is given by,

$$A_v = 20 \log \left(\frac{V_{out}}{V_{in}} \right) = 20 \log (0.707) = -3 \text{ dB}$$

The frequency f_c at this condition is called lower critical frequency and it is given by,

$$f_c = \frac{1}{2\pi R_{in} C_1}$$

where $$R_{in} = R_1 \| R_2 \| h_{ie}$$

$$\therefore \quad f_c = \frac{1}{2\pi (R_1 \| R_2 \| h_{ie}) C_1}$$

If the resistance of input source is taken into account the above equation becomes,

$$f_c = \frac{1}{2\pi (R_s + R_{in}) C_1}$$

The phase angle in an input RC circuit is expressed as

$$\theta = \tan^{-1}\left(\frac{X_{C1}}{R_{in}}\right)$$

Output RC network:

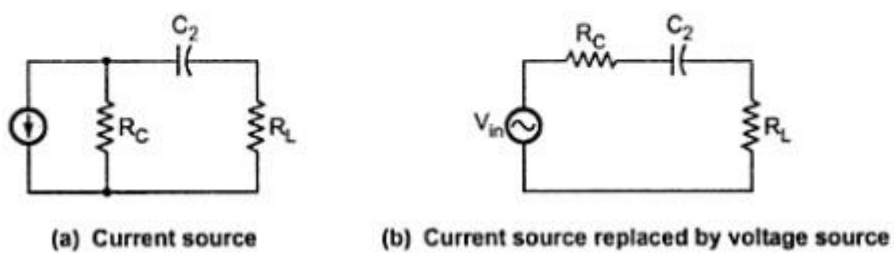

Figure 4.3.3 a Current Source & 4.3.3 b Current source replaced by Voltage Source

Diagram Source Brain Kart

The above figure 4.3.3 a and b shows Current Source & 4.3.3 b Current source replaced by Voltage Source the output RC network formed by C_2, resistance looking in at the collector and load resistance. The critical frequency for this RC network is given by,

$$f_c = \frac{1}{2\pi (R_C + R_L) C_2}$$

The phase angle in output RC network is given as,

$$\theta = \tan^{-1}\left(\frac{X_{C2}}{R_C + R_L}\right)$$

Bypass network:

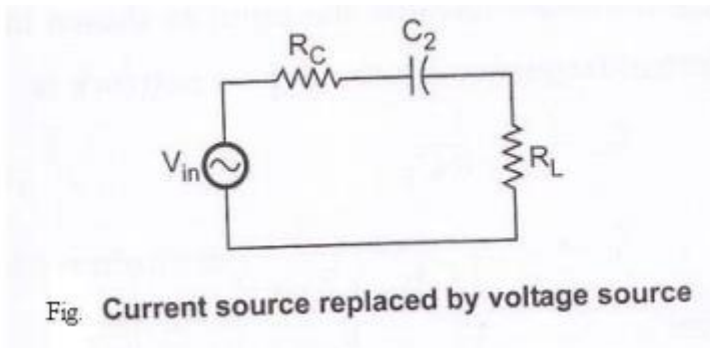

Figure 4.3.4 Current Source replaced by Voltage Source

Diagram Source Brain Kart

From above figure 4.3.4,

$$\left(\frac{h_{ie} + R_{TH}}{\beta}\right)$$

is the resistance looking in at the emitter. It is derived as follows, R= (V_b / βI_b) + h_{ie} / β

$$= \frac{I_b R_{TH}}{\beta I_b} + \frac{h_{ie}}{\beta} = \frac{R_{TH} + h_{ie}}{\beta}$$

Where $R_{TH} = R_1 \parallel R_2 \parallel R_s$. It is the thevenin's equivalent resistance looking from the base of the transistor towards the input.

The critical frequency for the bypass network is

$$f_c = \frac{1}{2\pi R C_E}$$

or

$$f_c = \frac{1}{2\pi\left[\left(\frac{h_{ie} + R_{TH}}{\beta}\right) \| R_E\right] C_E}$$