(3)

Continued to.– Expression for voltage gain in ... R.C. Coupled Amplifier

U/n–III

Low frequency gain

In this range, the reactance of the coupling capacitor is appreciable and cannot be neglected. In fact, this capacitor is primarily responsible for the fall of the gain of frequencies below the mid-band range. However, the reactance of the shunt capacitor may still be assumed infinite. Hence the ac equivalent circuit of an RC coupled transistor amplifier in the low frequency range is as shown in fig (2).

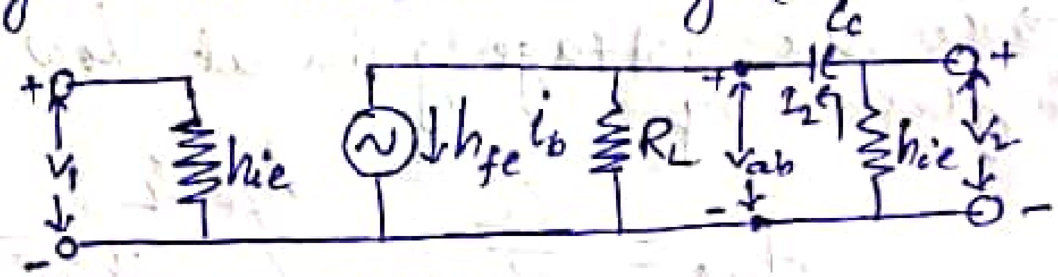

Fig (2)

The effective load impedance Z_L of the ~~amplitude~~ amplifier is given by

$$\frac{1}{Z_L} = \frac{1}{R_L} + \frac{1}{h_{ie} - j/\omega C_c} \longrightarrow (5)$$

where $\omega = 2\pi f$, f being a frequency in the low-frequency range. From equation (5), we get

$$Z_L = \frac{R_L(h_{ie} - j/\omega C_c)}{h_{ie} + R_L - j/\omega C_c} \longrightarrow (6)$$

Therefore, the potential ~~differentie~~ difference between the points a and b is

$$V_{ab} = -h_{fe} I_b Z_L \longrightarrow (7)$$

If I_2 be the current through h_{ie} and C_c, then

$$I_2 = -\frac{V}{h_{ie} - j/\omega C_c} = \frac{h_{fe} I_b Z_L}{h_{ie} - j/\omega C_c} \rightarrow (8)$$

Therefore, the output voltage V_2 is given by

$$V_2 = -h_{ie} I_2 = -\frac{h_{ie} h_{fe} I_b Z_L}{h_{ie} - j/\omega C_c} \rightarrow (9)$$

The input voltage is

$$V_1 = h_{ie} I_b \longrightarrow (10)$$

Hence the voltage gain at low frequencies is given by

$$A_{vl} = \frac{V_2}{V_1} = -\frac{h_{fe} Z_L}{h_{ie} - j/\omega C_c}$$

$$= -\frac{h_{fe} R_L}{h_{ie} + R_L - j/\omega C_c} \longrightarrow (11)$$

this equation shows that the gain is a complex quantity having a magnitude and a phase angle given by respectively by

$$|A_{vl}| = \frac{h_{fe} R_L}{\sqrt{(h_{ie}+R_L)^2 + 1/\omega^2 C_c^2}} \longrightarrow (12)$$

and $\theta_l = \pi + \text{arc}\tan\dfrac{1}{\omega C_c(h_{ie}+R_L)} \longrightarrow (13)$

Eq^n (11) may be written as

$$A_{vl} = \frac{(-h_{fe}R_L)/(h_{ie}+R_L)}{1 - j/\omega C_c(h_{ie}+R_L)}$$

$$= \frac{A_{vm}}{1 - j/2\pi f C_c(h_{ie}+R_L)} \longrightarrow (14)$$

Eq^n (14) gives the variation of A_{vl} with frequency in the low-frequency range, relative to the midband gain A_{vm}. At the lower half-power frequency f_l, the magnitude of the low-frequency voltage gain is $1/\sqrt{2}$ or 0.707 times the magnitude of the mid-frequency gain. Therefore, at $f = f_l$ we get

$$\frac{|A_{vm}|}{\sqrt{2}} = \frac{|A_{vm}|}{\sqrt{1 + 1/\{2\pi f_l C_c(h_{ie}+R_L)\}^2}} \longrightarrow (15)$$

or $2 = 1 + 1/\{2\pi f_l C_c(h_{ie}+R_L)\}^2$

or $2\pi f_l C_c(h_{ie}+R_L)^2 = 1$

$$\therefore f_l = \frac{1}{2\pi C_c(h_{ie}+R_L)} \longrightarrow (1$$

putting eq^n (16) in eq^n (14), we have

$$A_{vl} = \frac{A_{vm}}{1 - j(f_l/f)} \longrightarrow (17)$$

i.e $|A_{vl}| = \dfrac{|A_{vm}|}{1 + (f_l/f)^2}$ & $\phi_l = \pi + \text{arc}\tan(f_l/ \longrightarrow (18)$

Thus in this range of frequency, as f decreases, $|A_{v}|$ decreases and ϕ_2 increases.

(C) High-frequency gain

In this frequency range, the effect of the coupling capacitor is negligible. Hence its reactance is assumed to be zero. Thus the equivalent circuit of an RC coupled transistor amplifier can be shown in fig ③. Here C_{oe} represents the collector capacitance of the transistor and C_w represents the stray wiring capacitance. The ~~rule of~~ value of C_{oe} is related to that of C_{ob} specified in the data sheet by the relation:

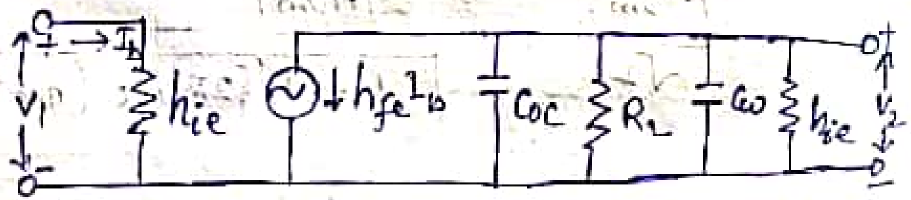

Fig ③

$$C_{oe} = \frac{C_{ob}}{1+h_{fb}} \longrightarrow (1)$$

Let $C_{os} = C_{oc} + C_w$, where C_{os} is the total capacitance in shunt across the output. The effective

load impedance Z_L of the amplifier is then given by

$$\frac{1}{Z_L} = \frac{1}{R_L} + \frac{1}{h_{ie}} + j\omega C_{os}$$

$$\text{or, } Z_L = \frac{h_{ie}R_L}{h_{ie}+R_L+j\omega C_{os}h_{ie}R_L} \longrightarrow (2)$$

Therefore, $V_2 = -h_{fe}I_b Z_L$

The gain in the high frequency range is

$$A_{vh} = \frac{V_2}{V_1} = \frac{-h_{fe}I_b Z_L}{h_{ie}I_b} = -\frac{h_{fe}Z_L}{h_{ie}} \longrightarrow (3)$$

Substituting the value of Z_L in equation ③, we get

$$A_{vh} = -\frac{h_{fe}R_L}{h_{ie}+R_L+j\omega C_{os}h_{ie}R_L} \longrightarrow (4)$$

$$= \frac{(-h_{fe}R_L)/(R_L+h_{ie})}{1+j\omega\frac{C_{os}h_{ie}R_L}{h_{ie}+R_L}}$$

$$= \frac{A_{vm}}{1+j\frac{2\pi f C_{os}h_{ie}R_L}{h_{ie}+R_L}} \longrightarrow$$

This equation gives the variation of A with frequency in the high frequency range, relative to mid band gain A_{vm}.