## SOLVED EXAMPLES

**Example 1.** *Draw a circuit diagram of two stage R-C coupled amplifier. Draw its a.c. equivalent circuit at mid-frequency range. Give expressions for* (1) *Input impedance,* (2) *Output impedance and* (3) *Voltage gain.*

The circuit diagram of two stage R-C coupled amplifier is shown in fig. (11 · 48).

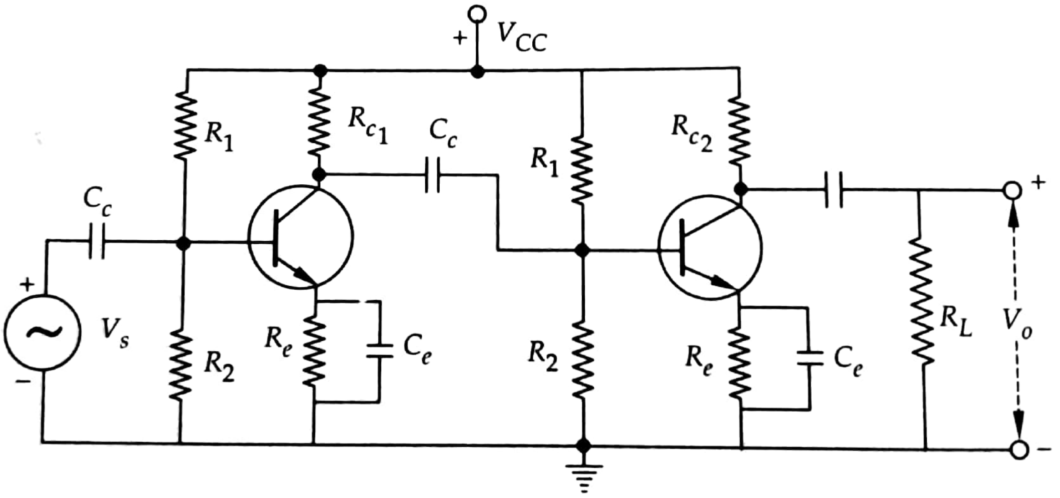


**Fig. 11·48** Two stage R-C coupled amplifier

Its a.c. equivalent circuit at mid-frequency range is shown in fig. (11 · 49).

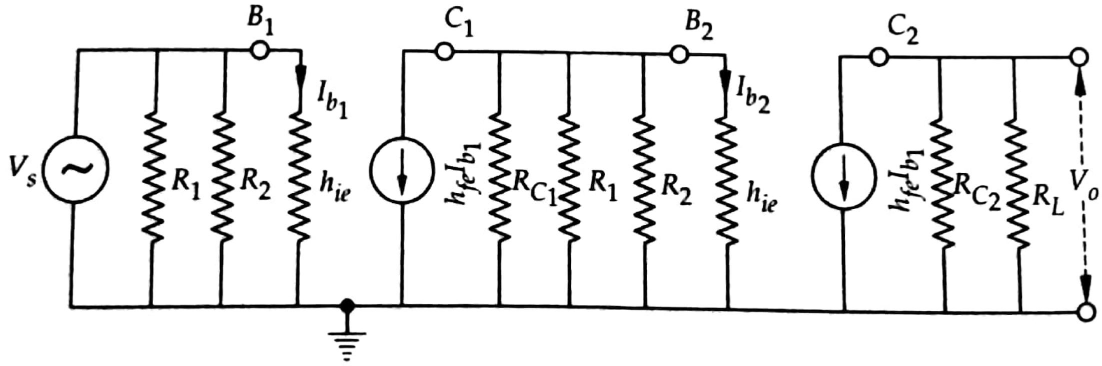


**Fig. 11·49** A.C. equivalent circuit of two stage R-C coupled amplifier

(1) ***Input impedance.*** The input impedance is a parallel combination of $R_1$, $R_2$, and $h_{ie}$. *i.e.*,

$$Z_i = R_1 \parallel R_2 \parallel h_{ie}$$

(2) ***The Output impedance.*** The output impedance is a parallel combination of $R_{C_2}$ and $R_L$. Hence

$$Z_o = R_{C_2} \parallel R_L$$

(3) ***Voltage gain*** $(A_v)_m$. The overall gain is given by

$$(A_v)_m = A_1 \times A_2$$

where, $A_1$ is the gain of first stage and $A_2$, the gain of second stage.

$$A_1 = \frac{-h_{fe}\ (R_{ac})_1}{h_{ie}}$$ where $(R_{ac})_1$ = output resistance of first transistor

$$(R_{ac})_1 = R_{C_1} \parallel R_1 \parallel R_2 \parallel h_{ie}$$

and $$A_2 = \frac{-h_{fe}\ (R_{ac})_2}{h_{ie}}$$, where $(R_{ac})_2$ = Output resistance of second transistor

$$(R_{ac})_2 = R_{C_2} \parallel R_L$$

**Example 2.** *A transistor is connected as a common-emitter amplifier with load resistance* $R_L = 10\ k\Omega$. *The h-parameters are* $h_{ie} = 5\ k\Omega$ *and* $h_{fe} = 330$. *Calculate the overall voltage gain for mid frequency range when four such stages are connected in cascade by RC coupling. Assume that source resistance is negligible to* $h_{ie}$.

The gain of R-C coupled amplifier at mid-frequency range is given by

$$(A_v)_m = -\frac{h_{fe}\ R_L}{h_{ie} + R_L}$$

For first stage, $$(A_{v_1})_m = -\frac{330 \times 10}{5 + 10} = -\frac{3300}{15} = -220$$

For second stage, $$(A_{v_2})_m = -\frac{330 \times 10}{5 + 10} = -220$$

For third stage, $$(A_{v_3})_m = -220$$

For fourth stage, $$(A_{v_4})_m = -\frac{h_{fe}\ R_L}{h_{ie}}$$

because the output of the fourth stage appears across $R_L$ only

$$= -\frac{330 \times 10}{5} = -660$$

$$\therefore \quad (A_v)_m = (A_{v_1})_m \times (A_{v_2})_m \times (A_{v_3})_m \times (A_{v_4})_m = 7 \times 10^9$$

**Example 3.** *A two-stage common emitter R-C coupled amplifier uses transistor of the type BC 149 B of which the h-parameters are* $h_{ie} = 4{\cdot}5\ k\Omega$ *and* $h_{fe} = 330$. *If the load resistance* $R_L = 5{\cdot}5\ k\Omega$, *find the required value of the coupling capacitor C so that the lower cut-off frequency is 60 Hz.*

We know that lower cut-off frequency $f_1$ is given by

$$f_1 = \frac{1}{2\pi C\ (h_{ie} + R_L)}$$

$$\therefore \quad C = \frac{1}{2\pi\ f_1\ (h_{ie} + R_L)}$$

Substituting the given values, we get

$$C = \frac{1}{2 \times 3.14 \times 60 \{(4.5 + 5.5) \times 10^3\}} = \frac{10^{-5}}{2 \times 3.14 \times 6} \text{ F}$$

$$= 0.026 \times 10^{-5} \text{ F} = \mathbf{0.26\ \mu F}$$

**Example 4.** *Design the circuit shown in fig.* (11·50), *called as Cascade circuit, to meet the following specifications:*

$V_{ce1} = V_{ce2} = 2.5$ V, $V_{RE} = 0.7$, $I_{c1} = I_{c2} \approx 1$ mA

and $I_{R1} \simeq I_{R2} \simeq I_{R3} \simeq 0.10$ mA

Neglecting base currents,

$$I_{Bias} = I_{R1} = I_{R2} = I_{R3} = 0.10 \text{ mA}$$

Now, $R_1 + R_2 + R_3 = \frac{V_{CC}}{I_{Bias}} = \frac{9}{0.10} = 90\text{ k}\Omega$

The voltage, $V_{B1}$ at the base of $Q_1$ is given by

$$V_{B1} = V_{RE} + V_{BE(on)} = 0.7 + 0.7 = 1.4\text{V}$$

$$\therefore \quad R_3 = \frac{V_{B1}}{I_{Bias}} = \frac{1.4}{0.10} = \mathbf{14\ k\Omega}$$

The voltage $V_{B2}$ at the base of $Q_2$ is given by

$$V_{B2} = V_{RE} + V_{CE1} + V_{BE(on)}$$

$$= 0.7 + 2.5 + 0.7 = 3.9\text{V}$$

$$\therefore \quad R_2 = \frac{V_{B2} - V_{B1}}{I_{Bias}} = \frac{3.9 - 1.4}{0.10} = \mathbf{25\ k\Omega}$$

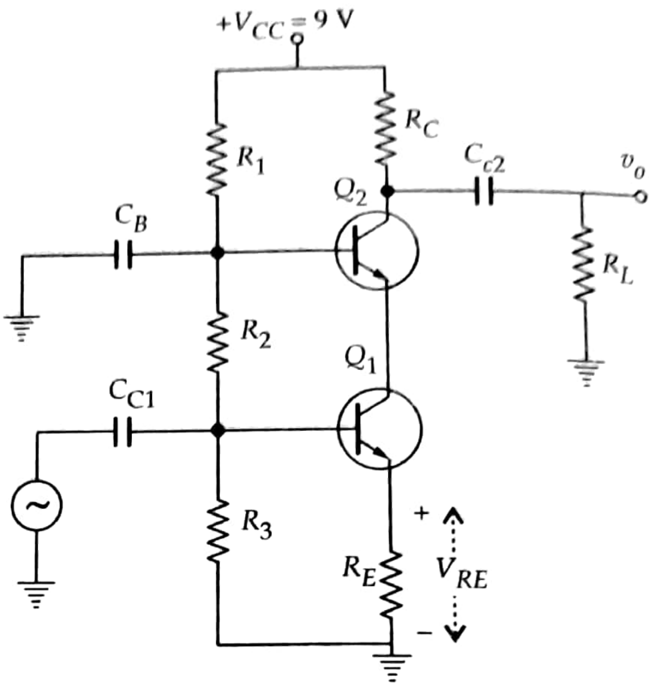


**Fig. 11·50** Cascade circuit

Now we obtain

$$R_1 = 90 - R_2 - R_3 = 90 - 25 - 14 = \mathbf{51\ k\Omega}$$

The emitter resistor $R_E$ is given by

$$R_E = \frac{V_{RE}}{I_{C1}} = \frac{0.7}{1} = \mathbf{0.7\ k\Omega}$$

The voltage at the collector of $Q_2$ is

$$V_{C2} = V_{RE} + V_{CE1} + V_{CE2} = 0.7 + 2.5 + 2.5 = 5.7 \text{ V}$$

$$\therefore \quad R_C = \frac{V_{CC} - V_{C2}}{I_{C2}} = \frac{9 - 5.7}{1} = \mathbf{3.3\ k\Omega}$$

**Example 1.** *The parameters of a transistor two stages R – C coupled amplifier are* $h_{fe} = 50$, $h_{ie} = 1{\cdot}1\ \text{k}\Omega$, $h_{oe} = 0$, *and* $R_L = 2\ \text{k}\Omega$. *Find (a) mid band gain, (b) value of coupling capacitor C to give a lower* 3 db *frequency of* 20 Hz, *(c) the value of C necessary to ensure less than* 10% *tilt for a* 100 Hz *square wave input.*

(a) $$(A_v)_m = \frac{h_{fe}\, R_L}{h_{ie} + R_L} = \frac{50 \times (2 \times 10^3)}{(1{\cdot}1 \times 10^3) + (2 \times 10^3)} = \mathbf{32{\cdot}26}$$

(b) The lower cut-off frequency $f$ is given by

$$f_1 = \frac{1}{2\pi C\, (h_{ie} + R_L)}$$

or

$$20 = \frac{1}{2\pi \times C\, [(1{\cdot}1 \times 10^3) + (2 \times 10^3)]}$$

Solving for $C$, we get

$$C = \mathbf{2{\cdot}567\ \mu F}$$

(c) Percentage tilt, $$P = \frac{\pi f_1}{f} \times 100$$

$$\therefore \quad f_1 = \frac{P\, f}{\pi \times 100} = \frac{10 \times 100}{100\, \pi} = \frac{10}{\pi}\ \text{Hz}$$

and

$$C = \frac{1}{2\pi \times (10/\pi)\, [(1{\cdot}1 \times 10^3) + (2 \times 10^3)]} = \mathbf{16{\cdot}13\ \mu F}$$

$\left( R_s + R_{ie} \right)$ ...(9)

**Example 1.** *The amplifier shown in fig.* [11·21 (a)] *uses a transistor with the following parameters:* $h_{ie} = 1 \cdot 1\ k\Omega$, $h_{fe} = 50$, $h_{re} = 2 \cdot 5 \times 10^{-4}$, $h_{oe} = 25 \times 10^{-6}$ A / V

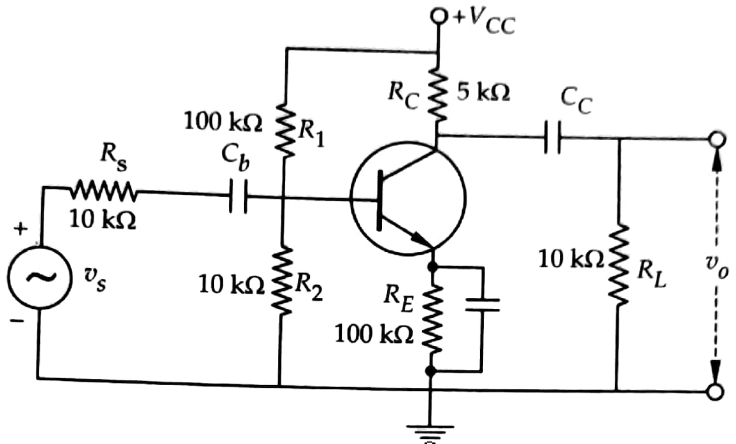


**Fig. 11·21 (a)**

*Calculate:* **(i)** $A_i$ *and* $A_{is}$, **(ii)** $A_v$ *and* $A_{vs}$, **(iii)** $R_o'$ *and* $R_i'$

The approximate hybrid equivalent circuit is shown in fig. [11·21 (b)].

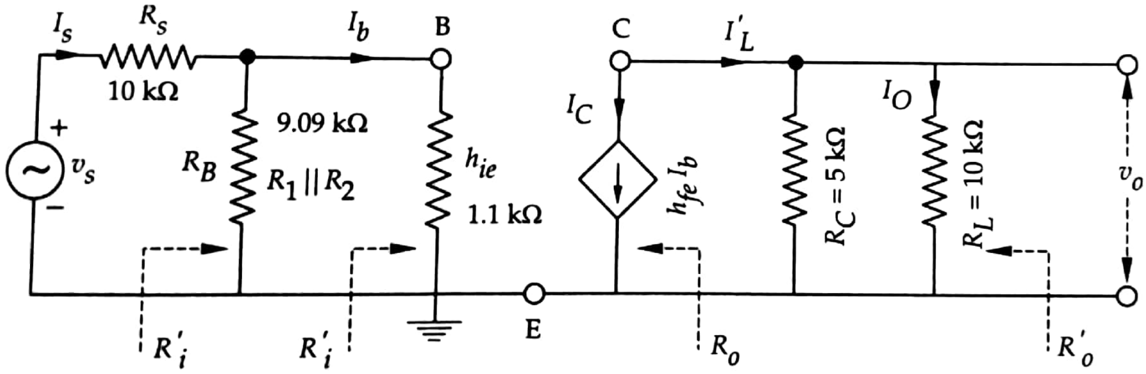


**Fig. 11·21 (b)** Equivalent circuit

From fig. [11·21 (b)], $R_i = h_{ie} = \mathbf{1 \cdot 1\ k\Omega}$

and $R_i' = h_{ie} \,||\, R_B = 1 \cdot 1\ k\Omega \,||\, (9 \cdot 09\ k\Omega) = \mathbf{981 \cdot 26\ \Omega}$

**(i)** $A_i = \dfrac{I_L'}{I_b} = \dfrac{h_{fe}\, I_b}{I_b} = h_{fe} = \mathbf{-50}$

$$A_{is} = \frac{I_L}{I_s} = \frac{I_L}{I_C} \times \frac{I_C}{I_b} \times \frac{I_b}{I_s}$$

From fig. [11·21 (b)], $\dfrac{I_L}{I_C} = \dfrac{-R_C}{(R_C + R_L)} \cdot \dfrac{I_C}{I_b} = h_{fe}$ and $\dfrac{I_b}{I_s} = \dfrac{R_B}{(h_{ie} + R_B)}$

$\therefore \quad A_{is} = \dfrac{-R_C\, h_{fe}\, R_B}{(R_C + R_L)(h_{ie} + R_B)}$

where $R_B = (R_1 \| R_2) = 9 \cdot 09$ kΩ.

Substituting all the values, we get

$$A_{is} = -\frac{(5 \times 10^3) \times 50 \times 9 \cdot 09 \times 10^3}{[(5 + 10) \times 10^3][9 \cdot 09 \times 10^3]} = \mathbf{-14 \cdot 87}$$

**(ii)** $A_v = A_i \times (R_L'/R_i) = A_i \left[\dfrac{(R_C \| R_L)}{R_i}\right]$

$$= -50\left[\frac{3 \cdot 33 \text{ k}\Omega}{1 \cdot 1 \text{ k}\Omega}\right] = \mathbf{-151 \cdot 52} \quad (\text{where } R_C \| R_L = 3 \cdot 33 \text{ k}\Omega)$$

$$A_{vs} = A_v \times \left[\frac{R_i'}{R_i' + R_s}\right] = -151 \cdot 52 \times \left[\frac{981 \cdot 26}{981 \cdot 26 + (10 \times 10^3)}\right]$$

or $A_{vs} = \mathbf{-13 \cdot 54}$

**(iii)** Here, $R_o = \infty$

and $R_o' = (R_o \| R_C \| R_L) = \infty \| (R_C \| R_L) = (R_C \| R_L)$

$R_o' = (5 \text{ k}\Omega \| 10 \text{ k}\Omega) = \mathbf{3 \cdot 33 \text{ k}\Omega}$