Module – 4

Unit – 4

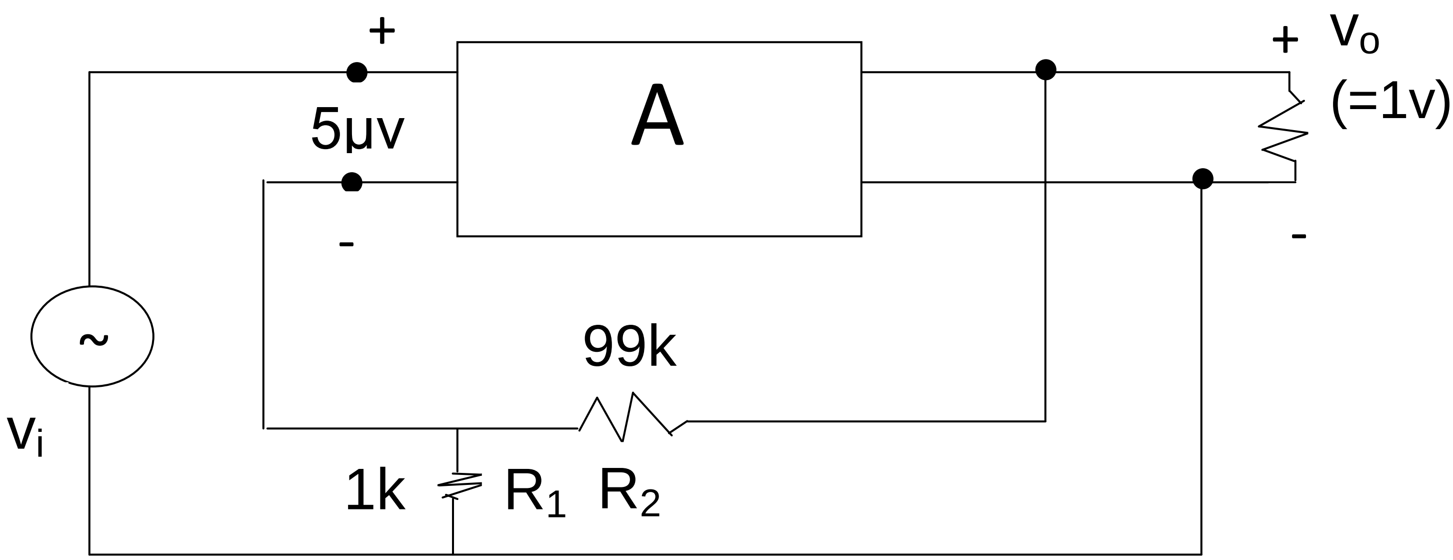
Feedback in Amplifiers

Review Questions:

1. What are the drawbacks in a electronic circuit not using proper feedback?
2. What is positive feedback? Positive feedback is avoided in amplifier circuits. Discuss.
3. Explain negative feedback. In what ways does it modify amplifier performance?
4. What are the different types of negative feedbacks? Draw appropriate circuits.
5. Write the basic expression for voltage gain of an amplifier with feedback and explain the terms used in the expression.
6. What type of feedback will you use in an amplifier to
   (i) Increase input impedance
   (ii) Decrease input impedance
7. Draw the gain-frequency response of an RC coupled amplifier. Discuss fall in gain at very low and at very high frequencies.
8. Two identical amplifier stages having gains of 50 each and phase shift between input and output signals of 180^o each are cascaded. How much is the over all gain and phase shift of 2-stage amplifier?
9. What are the different methods of coupling signals used in amplifiers? Discuss their advantages and disadvantages.
10. Two transistors having current gains of 100 and 80 respectively form Darlington pair. How much is current gain of the Darlington pair?

Problems:-

4.1 In the series – shunt feedback amplifier shown in fig. calculate the voltage gains without feedback, A, and with feedback A_{FB} .



Solution:-

The open loop gain A, is defined as the ratio of output voltage, v_o. to the error voltage, v_e, which is input to the basic amplifier.

Therefore,

$$\mathrm{A} = \frac{\mathrm{v_o}}{\mathrm{v_e}} = \frac{1V}{5 \times 10^{-6}V} = 2 \times 10^5$$
$$A = 2 \times 10^5$$

Voltage gain of feedback amplifier, A_{FB}, is expressed as,

$$A_{FB} = \frac{A}{1 + AB}$$

Where B is gain of the feedback network.

Since AB >> 1

$$A_{FB} = \frac{A}{AB} = \frac{1}{B}$$

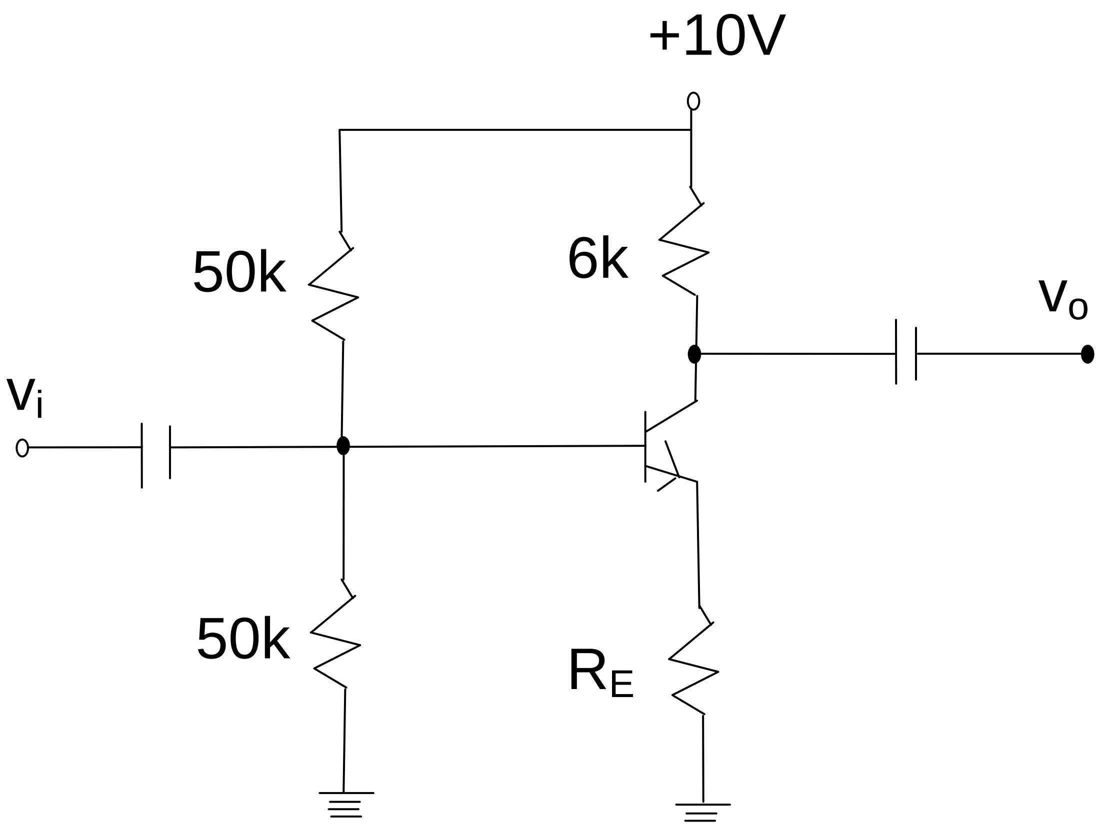
And B is,

$$B = \frac{R_1}{R_1 + R_2} = \frac{1k}{1k + 99k} = \frac{1}{100} = 0.01$$

Therefore,

$$A_{FB} = \frac{1}{B} = \frac{1}{0.01} = 100$$
$$A_{FB} = 100$$

4.2 Common emitter (CE) amplifier shown in fig. has voltage gain of 200 when $R_E = 0$. Stability is brought through negative feedback by adding resistor R_E. Calculate the value of resistor R_E using feedback concepts so that final voltage gain ($=A_{FB}$) is equal to 100.



Solution:-

The value of gain of feedback network, B can be obtained using the basic feedback relation,

$$A_{FB} = \frac{A}{1 + AB}$$

Since A_{FB} = 100 and A = 200, we have

$$100 = \frac{200}{1 + 200 \times B} \approx \frac{1}{B}$$

$$or \;\; B = \frac{1}{100}$$

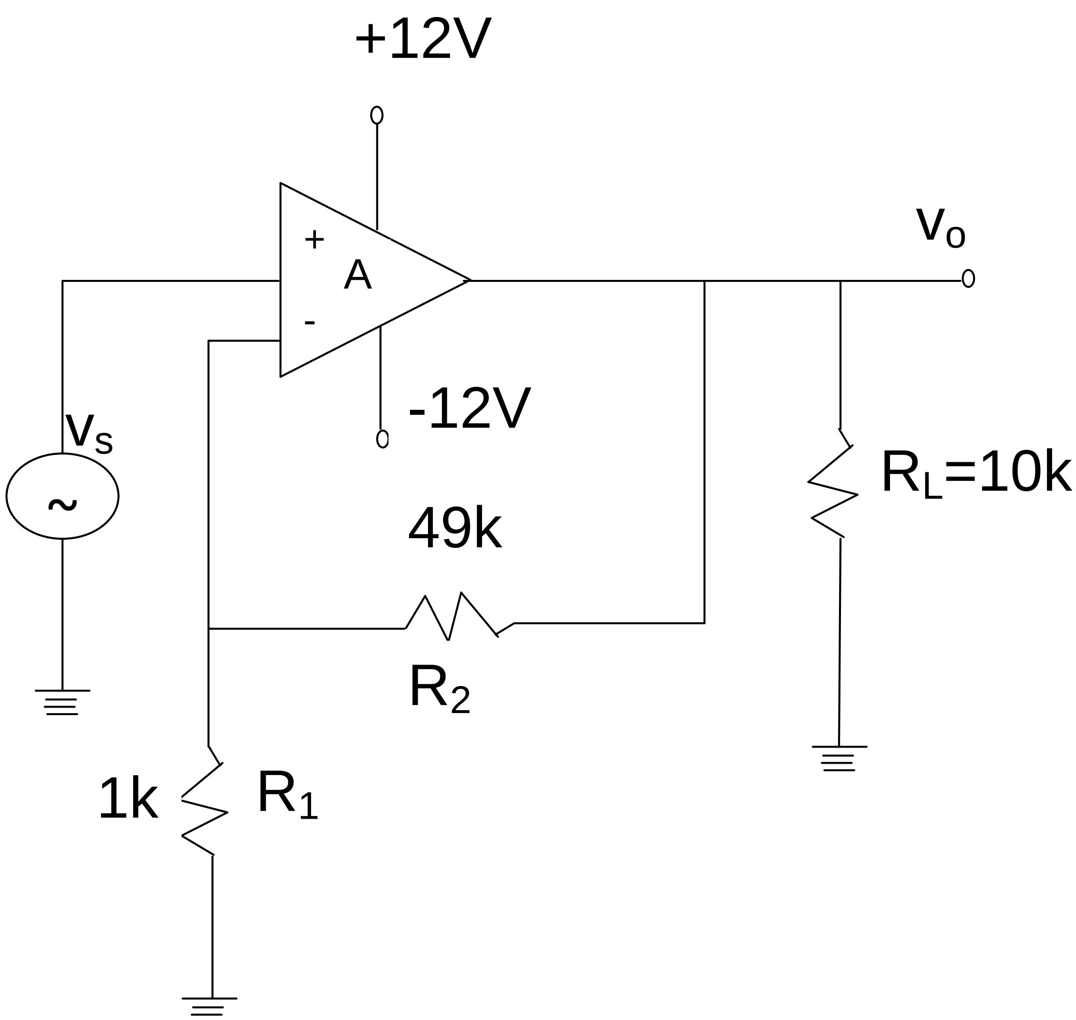
Further, the value of B is given by the ratio,

$$B = \frac{R_E}{R_C}$$

$$or, \; R_E = BR_C = \frac{6 \times 10^3}{100} = 60\,\Omega$$

$$R_E = 60\,\Omega$$

4.3 The feedback amplifier shown in fig. makes use of an op amp with internal gain (open loop gain) $A = 10^5$. How much is the output voltage for input signal $v_S = 2mV$ in the circuit shown.



Solution:-

The gain of feedback amplifier,

A_{FB}, is

$$A_{FB} = \frac{A}{1+AB} \cong \frac{1}{B}$$

Because AB>> 1

And, gain of feedback network, B, is

$$B = \frac{R_1}{R_1+R_2} = \frac{1k}{1k+49k} = \frac{1}{50}$$

Therefore,

$$A_{FB} = \frac{1}{B} = 50$$

And the output voltage, v_0, is

$v_o = A_{FB}$ X v_s

= 50 X 2 mV

or v_0 = 100 mV

4.4 An amplifier exhibits distortion in the form of voltage fluctuations of ~ 10%. These fluctuations are to be restricted to ~ 1% by incorporating negative feedback in the amplifier circuit. If ultimate gain is desired to be 120, what should be the open loop gain of the amplifier?

Solution:-

The distribution, D_{FB} in an amplifier with feedback and distortion, D without feedback in the amplifier are related as,

$$D_{FB} = \frac{D}{(1+AB)}$$

Where A is open loop gain of amplifier and B is the gain of feedback network.

$$Now,\ D = 10\% = \frac{10}{100}\ \ (given)$$

$$and\ \ D_{FB} = 1\% = \frac{1}{100}\ \ (given)$$

Therefore, using above equation,

$$\frac{1}{10} = \frac{1}{(1+AB)}$$

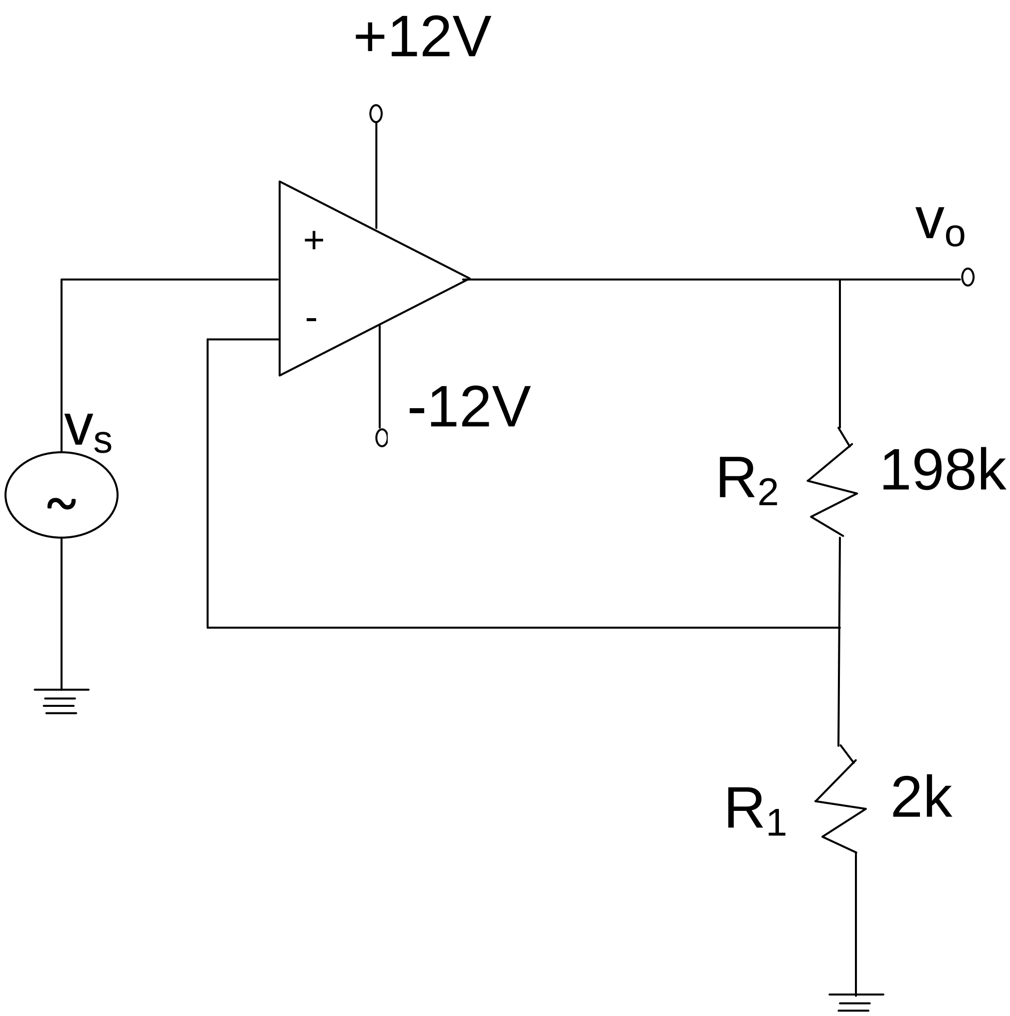
$$or,\ (1+AB) = 10$$

$$Now,\ A_{FB} = \frac{A}{(1+AB)} = \frac{A}{10}$$

$$or, A = 10 \times A_{FB} = 10 \times 120 \quad (\because\ A_{FB} = 120)$$

$$or,\ A = 1200$$

4.5 Figure shows an op amp circuit with voltage series feedback through resistors R_1 and R_2. The internal gain of op amp is 5×10^4 and input impedance is 100kΩ . Find out the gain and input impedance of the amplifier with feedback.



Solution:-

The gain of amplifier with feedback, A_{FB}, is

$$A_{FB} = \frac{A}{1 + AB}$$

Where A is open loop gain of amplifier and B is gain of feedback network.

Since AB>> 1

$$A_{FB} = \frac{A}{1 + AB} \approx \frac{1}{B}$$

$$Now,\ B = \frac{R_1}{R_1 + R_2} = \frac{2k}{2k + 198k} = \frac{1}{100}$$

Therefore,

$$A_{FB} = \frac{1}{B} = 100$$

$$A_{FB} = 100$$

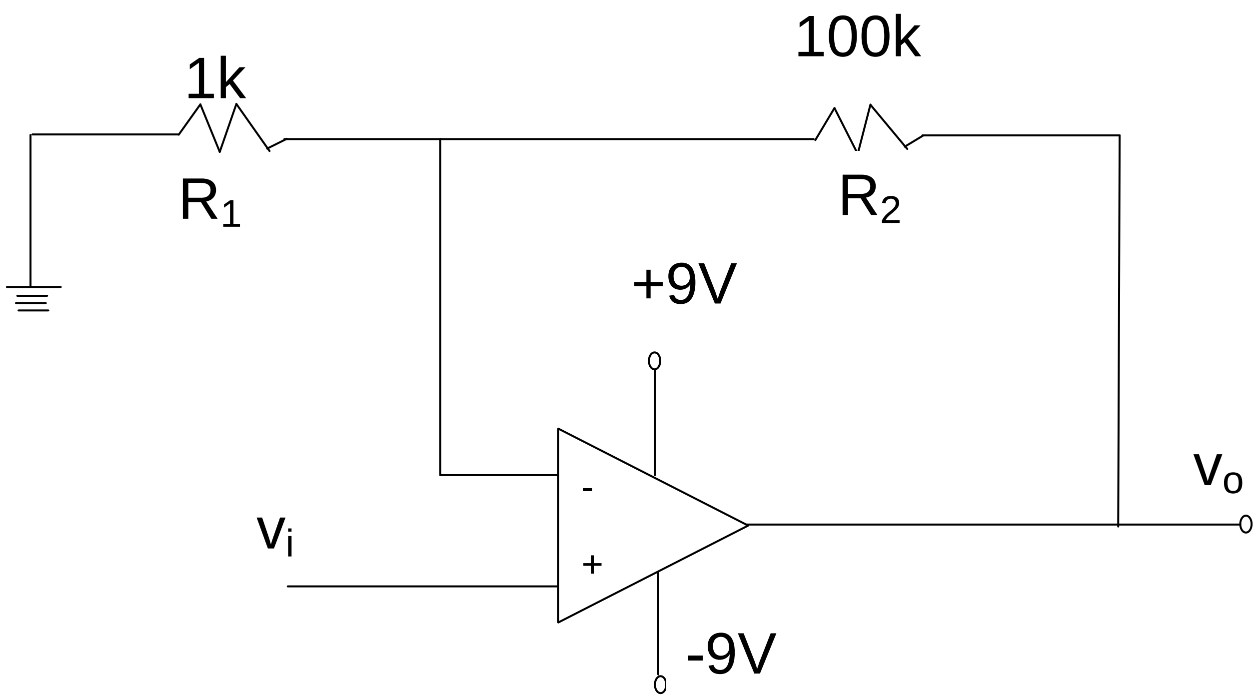
The input impedance with and without feedback in a voltage-series circuit are related as,

$Z_{i(FB)} = (1 + AB)\ Z_i \approx ABZ_i$

Or $Z_{i(FB)} = 5 \times 10^4 \times 10^{-2} \times 100k$

Or $Z_{i(FB)} = 50\ M\Omega$

4.6 An op amp has open loop band width of 5Hz at gain 2×10^5. Feedback is incorporated and resistors R_1 and R_2 form the feedback network. Find the bandwidth of the amplifier shown in fig.



Solution:-

The gain of feedback network, B, in the circuit of fig. is

$$B = \frac{R_1}{R_1 + R_2} = \frac{1k}{1k + 100k} \approx \frac{1}{100} = 10^{-2}$$

The bandwidth with feedback, $f_{(FB)}$ and without feedback (Open loop bandwidth), f_2, are related as

$f_{(BW)} = (1 + AB)\, f_2$

Where A is open loop gain of op amp

or $f_{(BW)} \approx ABf_2$

or $f_{(BW)} = 2 \times 10^5 \times 10^{-2} \times 5\ H_Z$

or $f_{(BW)} = 10\ kH_Z$

4.7 Two RC coupled amplifiers are connected to form a 2-stage amplier. If the lower and upper cutoff frequencies of each individual amplifier respectively are 100 H_Z and 20 kH_Z, What these frequencies are for the 2-stage amplifier?

Solution:-

For multi-stage amplifier consisting of n identical amplifying stages, the lower cut off $f_{1(multi)}$ is expressed as,

$$f_{1(multi)} = \frac{f_1}{\sqrt{2^{1/n} - 1}} \qquad (1)$$

Where f_1 is lower cut-off of individual stages.

And the upper cutoff $f_{2(multi)}$ is expressed as,

$$f_{2(multi)} = f_2\sqrt{2^{1/n} - 1} \qquad (2)$$

Where f_2 is upper cut-off of individual stages.

Therefore, the lower cut-off of 2-stages amplifier (Eq(1)) is

$$f_{1(2-stage)} = \frac{100}{\sqrt{2^{1/2} - 1}} = \frac{100}{0.643}$$

$$or \;\; f_{1(2-stage)} = 155.5 \; H_Z$$

Similarly, the upper cutoff of the 2-stage amplifier (Eq 2) , is

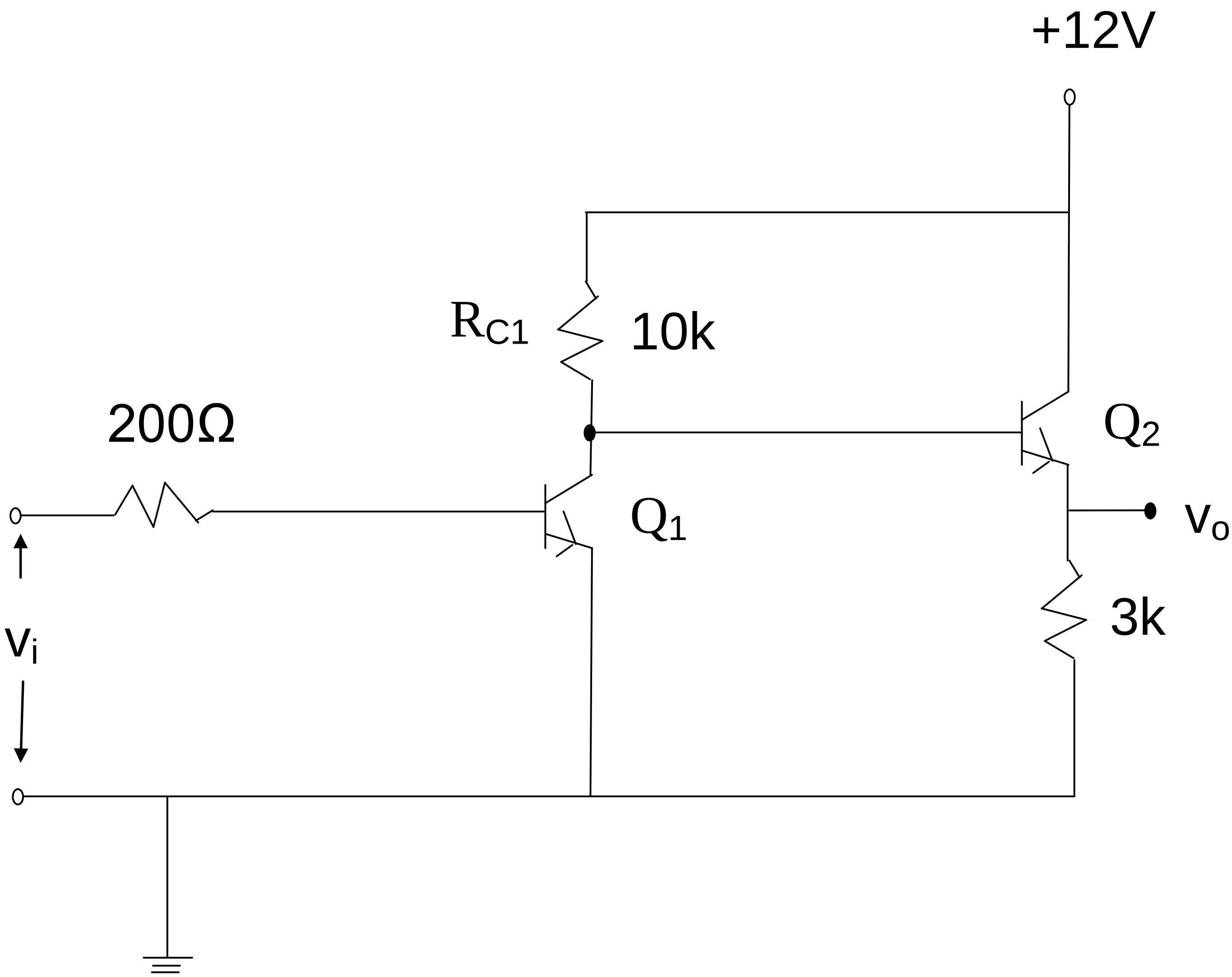
$$f_{2(2-stage)} = f_2\sqrt{2^{1/2} - 1}$$

$$20\times 0.643 kH_Z$$

$$or \;\; f_{2(2-stage)} = 12.8 \; kH_Z$$

Thus the band width gets reduced in a multi-stage amplifier.

4.8 The two-stage amplifier shown in fig uses transistors Q_1 and Q_2, both having current gain β of 80 and dynamic emitter resistance, r'_e, of 25 Ω each. Find out the over all voltage gain of the amplifier.



Solution:-

In a multi-stage amplifier, it is convenient to analyse the last stage (output stage) first.

In the present case, the last stage (Q_2 – stage) is emitter follower which has voltage gain of unity. Then the over all gain of two-stage amplifier(product of gains of individual stages) is same as gain of first stage which is common emitter amplifier in fig.

The gain of CE amplifier is

$$A_V = A_{V1} = \frac{r_{c1}}{r_{E1} + r'_e}$$

Since $R_E = 0$ (for Q_1 transistor), $r_{E1} = 0$

Then,

$$A_V = \frac{r_{c1}}{r'_e}$$

Where r_{c1} is the effective impedence seen by the collector of transistor Q_1.

That is,

$r_{c1} = R_{C1} \| Z_{i(base)2}$

The impedance, $Z_{i(base)2}$ at the base of transistor Q_2 is,

$Z_{i(base)2} = \beta .\ R_{E2}$

$= 80 \times 3k$

or $Z_{i(base)2} = 240k\Omega$

Therefore,

$R_{c1} = R_{C1} \| Z_{i(base)2}$

$= 10k \| 240k$

or $r_{c1} = 9.6\ k\Omega$

Therefore, over all gain of amplifier of fig is

$$A_V = \frac{r_{c1}}{r'_e} = \frac{9.6 \times 10^3}{25} = 384$$

$$or \quad A_V = 384$$