Module – 6

Unit – 6

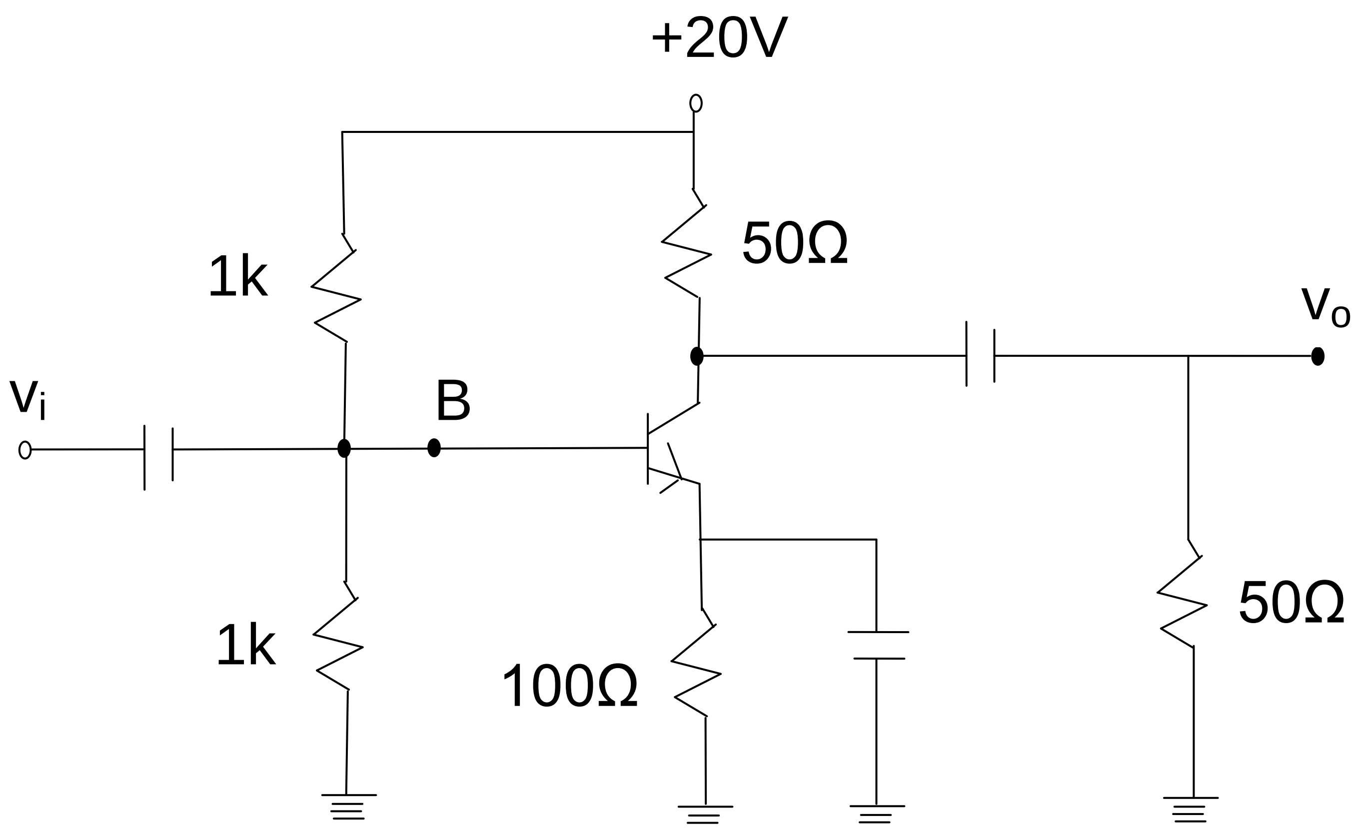
Power Amplifiers

Review Questions:

1. In what way the design features of power transistors different from small signal transistors?
2. What is the basis for the classification of power amplifiers? Mention different types of power amplifiers?
3. Draw the circuit for commonly used class A – amplifier. If the amplifier draws 10W of dc power, what is the maximum ac power available to the load?
4. Draw the circuit for a push-pull amplifier and discuss its working.
5. Derive an expression for the efficiency of class B – power amplifiers.
6. What is harmonic distortion? How does it arise in Class B-operation? And, how can it be corrected in push-pull circuit?
7. What do you understand by cross-over distortion? How can it be eliminated in Class B-operation?
8. What reasons will you assign for higher conversion efficiency of Class B-amplifier as compared to Class A –amplifier?
9. Draw a circuit for Class C- amplifier and discuss its working?
10. Among all the power amplifiers, Class C-amplifier has the maximum efficiency but its use is restricted. Give reasons.

Problems:

6.1 Calculate maximum ac output power in the amplifier shown in fig. (Assume V_{BE} = 0)



Solution:-

The ac power in class A-operation, P_0 is given by the relation,

$$P_0 = \frac{V_{CEQ} \cdot I_{CQ}}{2}$$

Where V_{CEQ} and I_{CQ} are voltage across collector – emitter of transistor at operating point and collector current respectively.

First we need the value of I_{CQ}. Now in fig above, the voltage between base and ground (point B and ground, see fig.) V_{BB}, is 10 V.

Then,

$$I_{CQ} = I_E = \frac{V_{BB} - V_{BE}}{R_E} = \frac{V_{BB}}{R_E}$$

$$= \frac{10V}{100\Omega} = 100\,mA$$

V_{CEQ} can be obtained by summing voltage (dc voltages, capacitors taken open)

$V_{CC} = V_{CEQ} + I_E(R_C + R_E)$

Or, $V_{CEQ} = V_{CC} - I_E(R_C + R_E)$

$= 20 - 100\text{mA}\ (50 + 100)\Omega$

$= 20 - 15$

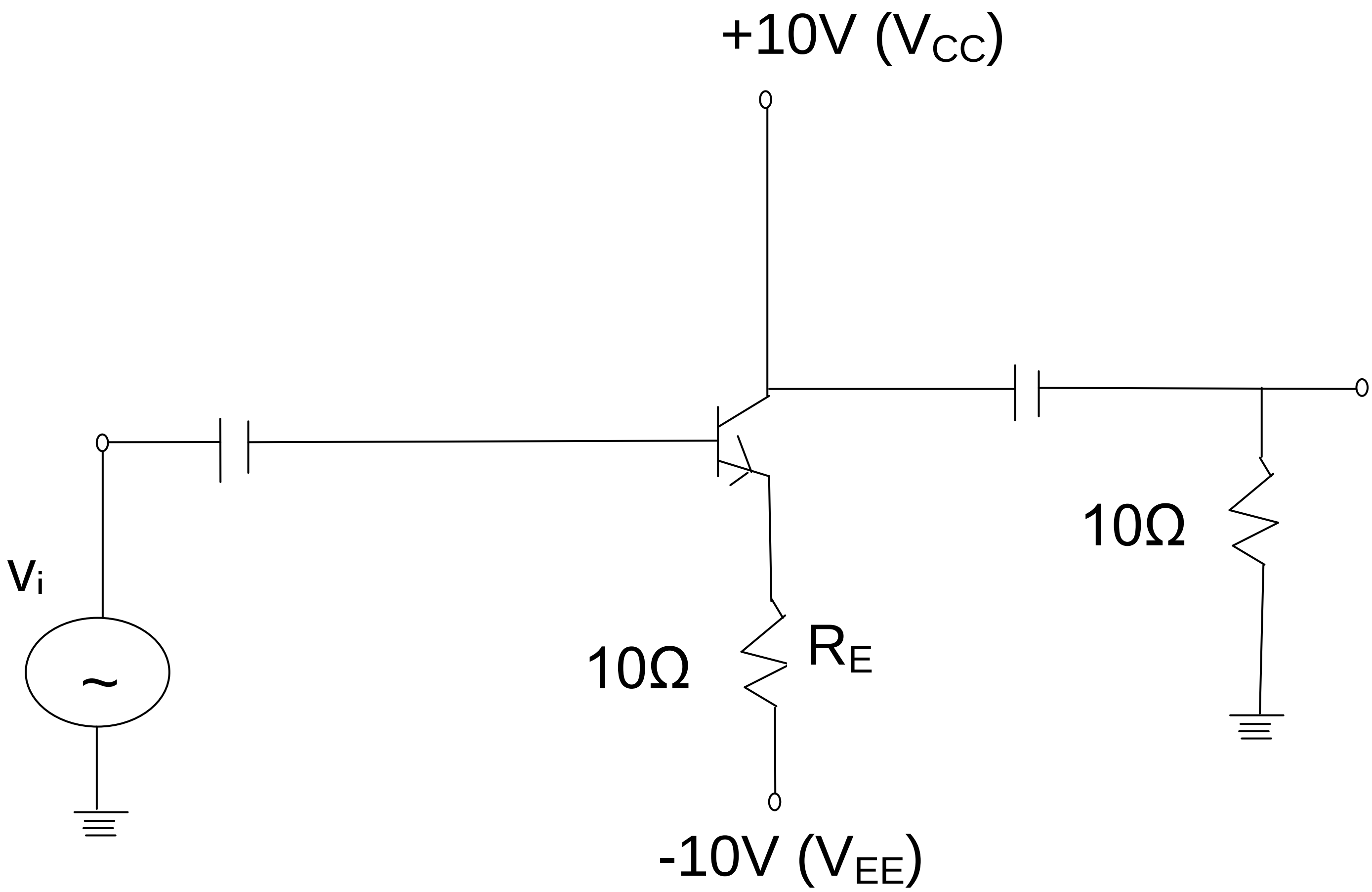
Or, $V_{CEQ} = 5\text{V}$

Therefore, maximum ac power, P_O,

$$P_0 = \frac{V_{CEQ} \cdot I_{CQ}}{2} = \frac{5 \times 100\,mA}{2}$$

$$or \quad P_0 = 250\,mW$$

6.2 Calculate maximum ac output power and efficiency of the amplifier shown in fig. V_{BE} may be assumed negligibly small.



Solution:-

The operating point current and voltages in the circuit are:

$$I_{CQ} = I_E = \frac{|V_{EE}|}{R_E} = \frac{10V}{10\Omega} = 1A$$

And,

$V_{CEQ} = V_{CC} = 10V$

Therefore, maximum ac output power is,

$$P_{0(\max)} = \frac{V_{CEQ}.I_{CQ}}{2} = \frac{10\times 1}{2} = 5W$$

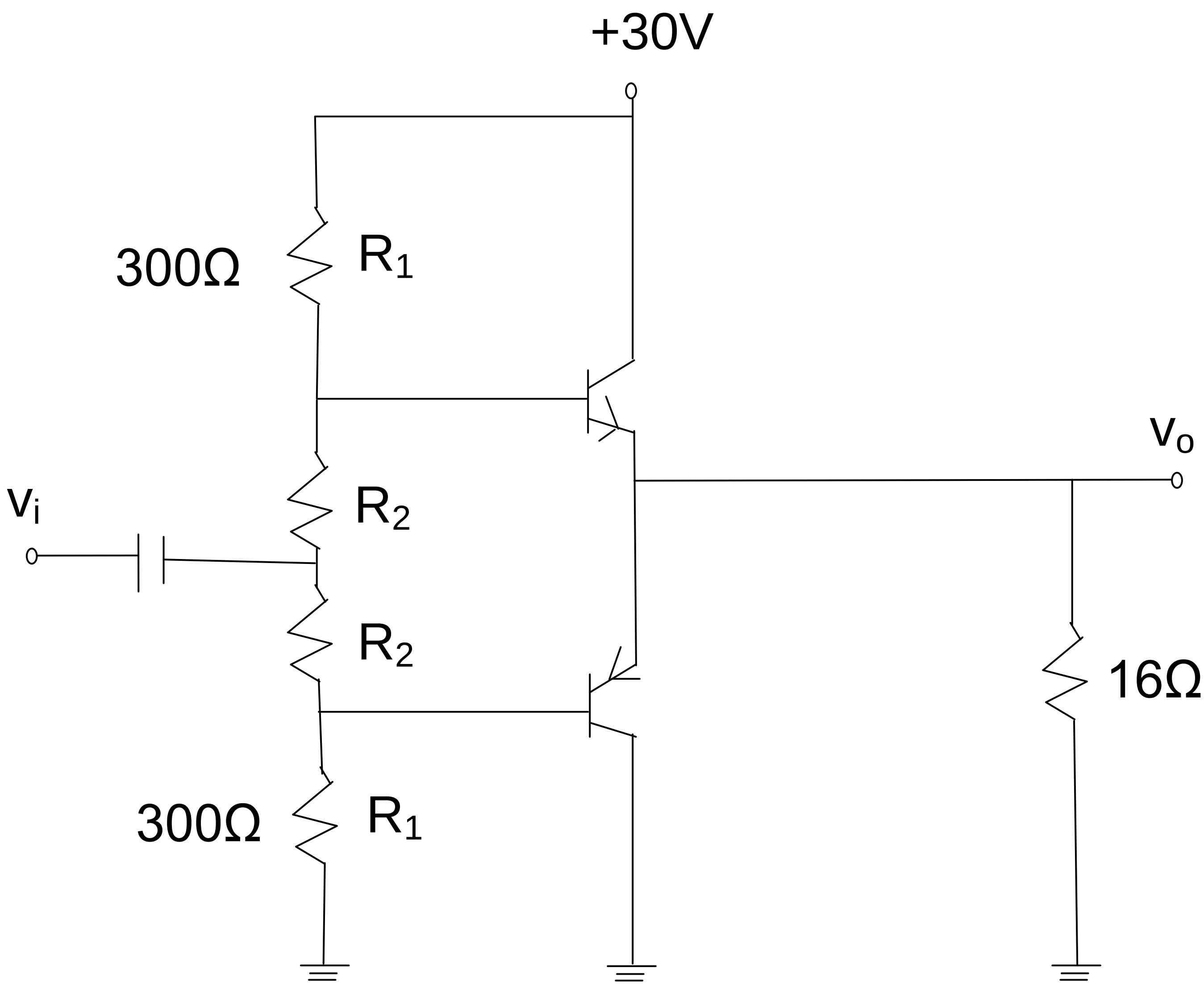
To calculate the efficiency, η , the dc power drawn by collector-emitter circuit is,

$$\begin{aligned} P_{DC} &= \left|V_{CC}\right| + \left|V_{EE}\right| \; I_{CQ} \\ &= (10+10)\times 1 = 20W \end{aligned}$$

Therefore efficiency,

$$\eta = \frac{P_{0(\max)}}{P_{DC}} = \frac{5W}{20W}\times 100$$
$$or\ \eta = 25\%$$

6.3 Find out the value of resistor R_2 to provide trickle current for distortion free output in the push pull amplifier shown in fig. V_{BE} for each transistor is 0.7V.



Solution:-

Trickle current which flows through resistors R_2 and produces a voltage drop of 0.7 V across base – emitter junction over comes cross – over distortion in push – pull amplifier. For analysis purposes, it is sufficient to consider only half of the circuit for reasons of symmetry, and V_{CC} of half (= $V_{CC}/2 = 30/2 = 15V$) is to be taken for one transistor.

The current through resistors R_1 and R_2 is,

$$I = \frac{15V}{R_1 + R_2} = \frac{15V}{300\,\Omega + R_2} \qquad ....(A)$$

But,

I X R_2 = 0.7V (desired voltage)

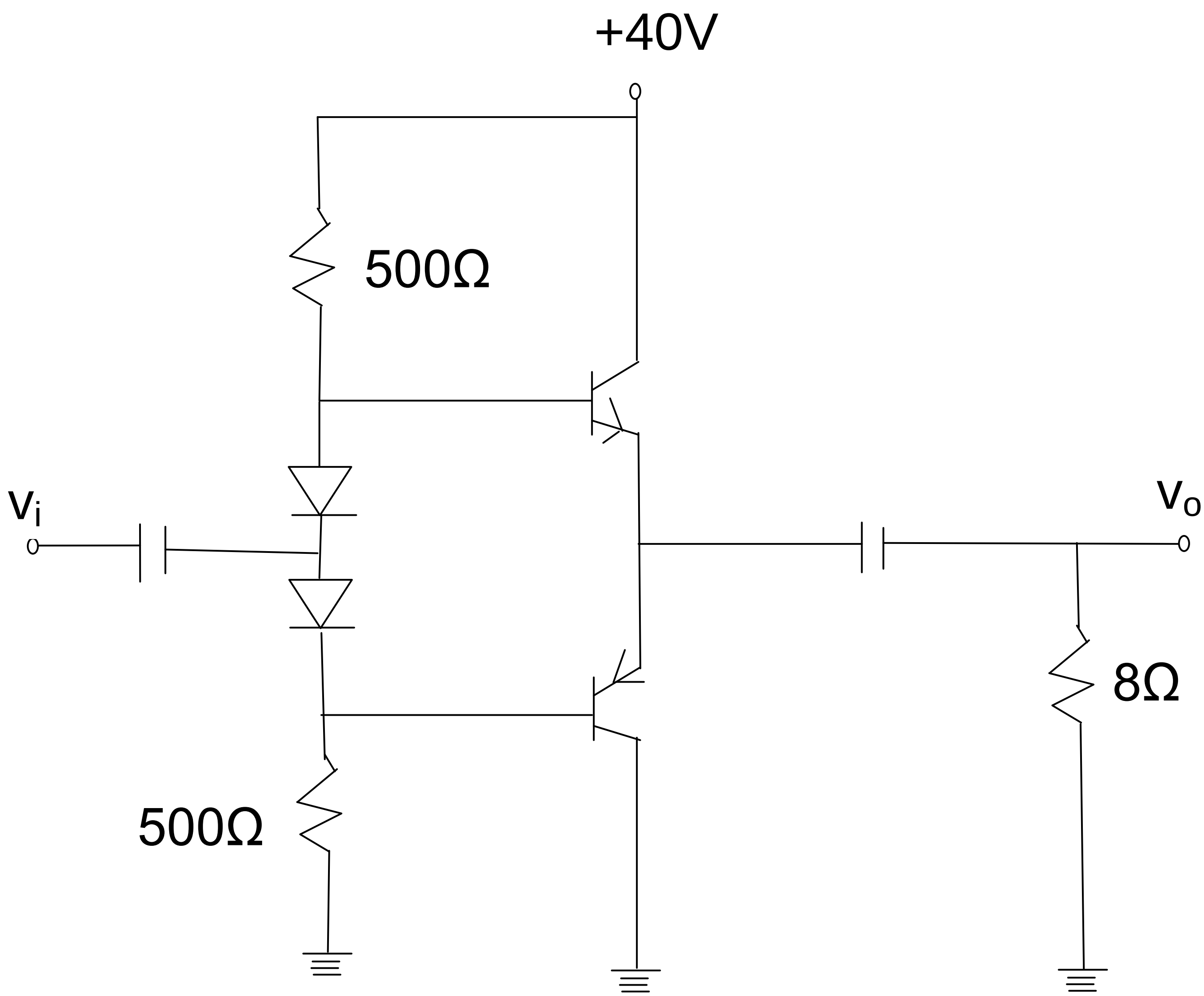
$$or, I = 0.7V / R_2 \qquad ....(B)$$

Combining Eqs (A) and (B),

$$\frac{0.7V}{R_2} = \frac{15V}{300\Omega + R_2}$$

$$or,\ R_2 = 14.7\,\Omega$$

6.4 Calculate maximum ac output power and the minimum power rating of the transistors in the push-pull amplifier shown in fig.



Solution:-

The maximumac power (output). $P_{0(max)}$ as per the discussion on the topic is,

$$P_{0(\max)} = \frac{V_{CEQ} \times i_{c(sat)}}{2}$$

Where $i_{c(sat)}$ is maximum (saturated) collector current.

Now,

$$V_{CEQ} = \frac{1}{2}V_{CC} = \frac{1}{2} \times 40V = 20V$$

And, $i_{c(sat)}$ is expressed as,

$$i_{c(sat)} = \frac{V_{CEQ}}{r_C + r_E} = \frac{20V}{0 + 8\Omega} = 2.5A$$

Here, r_C is effective ac resistance seen by the collector and r_E is effective resistance seen by the emitter.

Therefore,

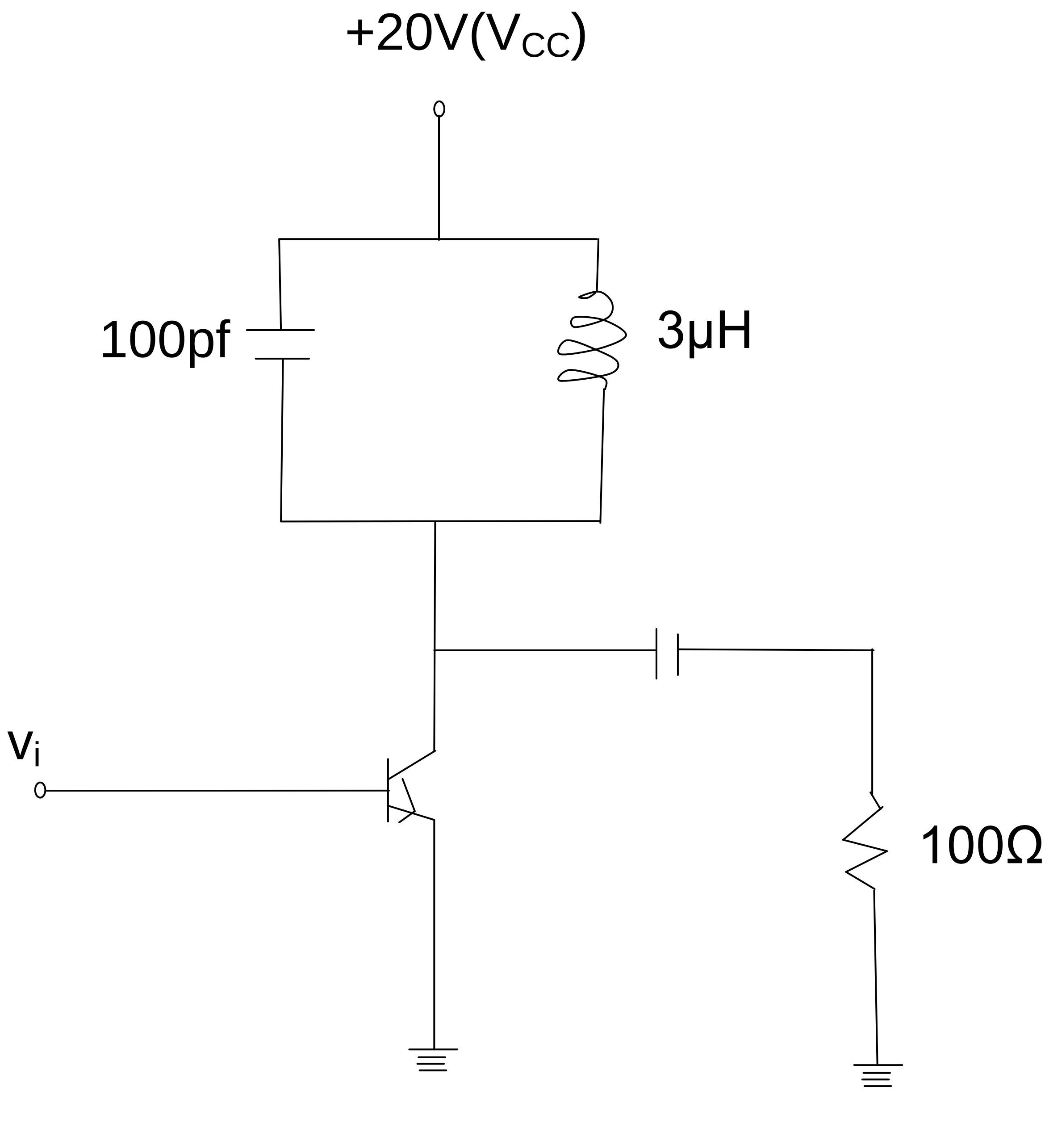
$$P_{0(\max)} \frac{V_{CEQ} \times i_{C(sat)}}{2} = \frac{20 \times 2.5}{2} = 25\ W$$

The maximum power rating, $P_{D(max)}$ is one-fifth of maximum ac power. That is,

$$P_{D(\max)} = \frac{1}{5} \cdot P_{0(\max)} = \frac{25W}{5}$$

$$or,\ P_{D(\max)} = 5W$$

6.5 In fig. a basic Class C-amplifier is shown. It uses supply voltage of + 20V and load resistance of 100Ω. The operating frequency is $3MH_Z$ and $V_{CE(sat)} = 0.3$ V. Calculate and efficiency. If peak current is 500 mA, find the conduction angle also.



Solution:-

The peak voltage, V_p, as was discussed is,

$V_p = V_{CC} – V_{CE(sat)} = 20 – 0.3$

Or, $V_p = 19.7V$

The ac power P_0, is

$$P_0 = \frac{V_p^2}{2R_L} = \frac{1.97^{\ 2}}{2 \times 100}$$
$$or,\ P_0 = 1.69W$$

And, dc power drawn by the circuit is,

$$P_{dc} = V_{CC} \times I_{dc}$$

Where,

$$I_{dc} = \frac{P_0}{V_p} = \frac{1.69W}{19.7V} = 0.0857\,A$$

Therefore,

$P_{dc} = 20 \text{ X } 0.0857$

or, $P_{dc} = 1.714$ W

And the efficiency, η, is

$$\eta = \frac{P_0}{P_{dc}} = \frac{1.69W}{1.714W} \times 100 = 98.5\%$$

Now, we proceed to find out the conductance angle θ.

For the frequency of 3MH$_Z$, the period of the wave, T, is

$$T = \frac{1}{3 \times 10^6} = 0.33\,\mu s$$

And transistor's on- time is,

$$t = \frac{P_0 \times T}{I_p \times V_p}$$

$$= \frac{1.69W \times 0.33\times10^{-6}}{500\times10^{-3} \times 19.7V}$$

$$or,\ t = 56.6 \times 10^{-9}\ s$$

$$or,\ t = 56.6\ ns$$

And, the conduction angle, θ, is

$$\theta = \frac{t}{T} \times 360 = \frac{56.6 \times 10^{-9}}{0.33 \times 10^{-6}} \times 360$$

$$or, \theta = 61.7^{\bullet}$$