Power Amplifier

Power Amplifier

POWER CALCULATION: Transistor Amplifier

In Transistor Amplifier, as all in sections both dc & ac current is flowing, so it has to be checked DC power & AC power are separable or not.

$$V(t) = V_{dc} + v(t)$$
$$I(t) = I_{dc} + i(t)$$

$$p = V(t)\,I(t) = \text{Instantaneous power}$$

$$P = \text{Average Power} = \frac{1}{T}\int_0^T V(t)\,I(t)\,dt$$

$$= \frac{1}{T}\int_0^T \left[V_{dc} + v(t)\right]\left[I_{dc} + i(t)\right]dt$$

$$= \frac{1}{T}\int_0^T V_{dc} I_{dc}\,dt + \underbrace{\frac{1}{T}\int_0^T V_{dc}\,i(t)\,dt}_{=0} + \underbrace{\frac{1}{T}\int_0^T I_{dc}\,v(t)\,dt}_{=0} + \frac{1}{T}\int_0^T v(t)\,i(t)\,dt$$

$$= V_{dc} I_{dc} + \frac{1}{T}\int_0^T v(t)\,i(t)\,dt$$

$$\boxed{P = P_{dc} + P_{ac}}$$

- So they are separable. For power calculation ac power can be considered only.

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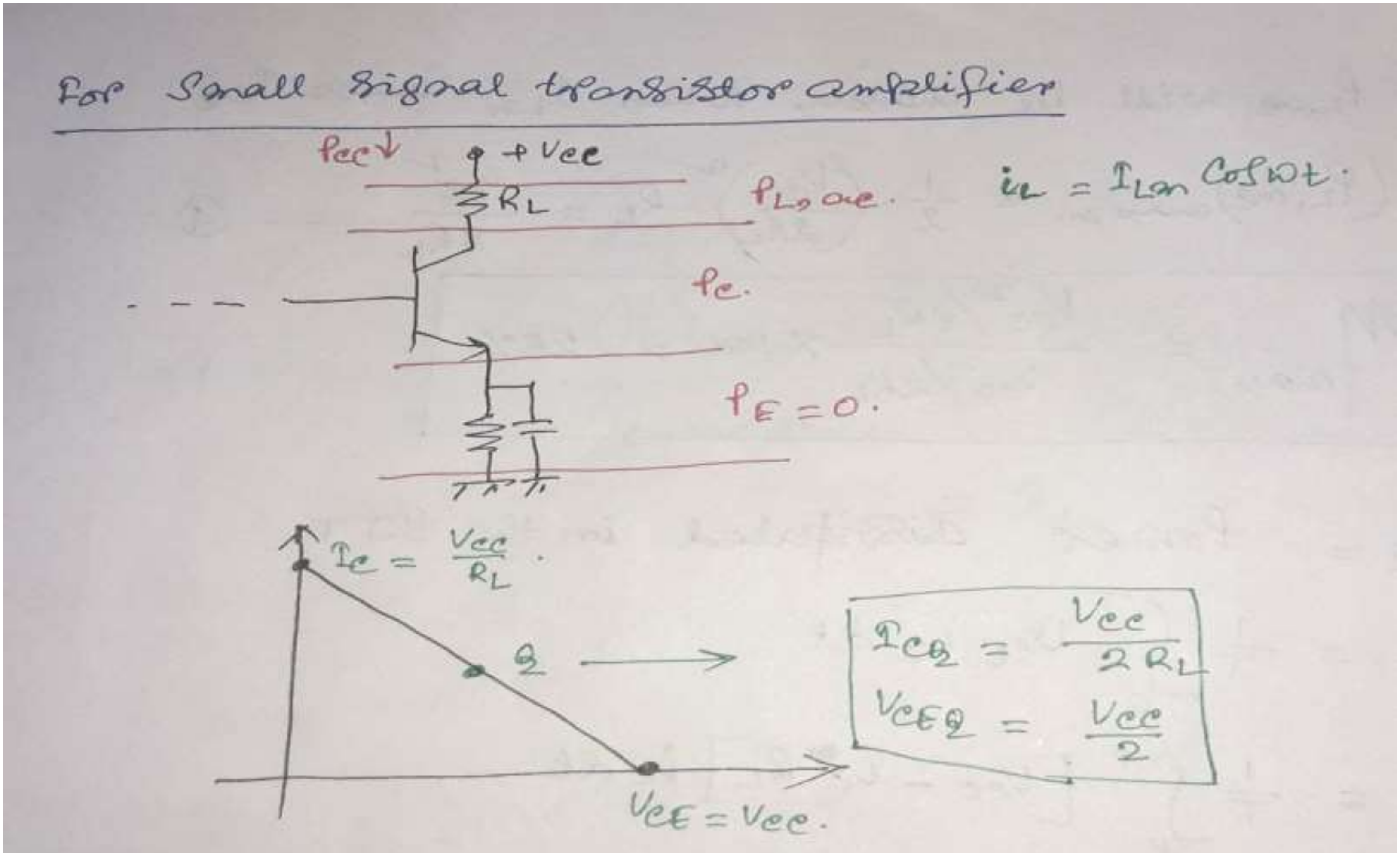

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Power Calculations

P_{cc} = Power Supplied to the amplifier

$$= V_{cc} \cdot I_{CQ} = \frac{V_{cc}^2}{2R_L} \quad \text{- - - - - (1)}$$

$$P_{L,ac} = \frac{1}{T}\int_0^T i_L^2 \, dt . R_L = \text{load power dissipation}$$

$$= \frac{1}{T}\int_0^T I_{Lm}^2 \cos^2 \omega t \, d(\omega t) \, . \, R_L$$

$$\boxed{P_{L,ac} = \frac{1}{2} I_{Lm}^2 R_L} \quad \text{- - - - - (2)}$$

$$\eta = \frac{P_{L,ac}}{P_{cc}} = \text{Efficiency} = \frac{\frac{1}{2} I_{Lm}^2 R_L}{V_{cc}^2 / 2R_L} \quad \text{- - - (3)}$$

Power Amplifier

$P_{L,ac}$ will be max. when $I_{Lm} = \max. I_{CQ}$

$$(P_{L,ac})_{max.} = \frac{1}{2}\cdot\left(\frac{V_{CC}}{2R_L}\right)^2\cdot R_L = \frac{V_{CC}^2}{8R_L} \quad \text{---} \quad (4)$$

$$\boxed{\eta_{max.} = \frac{V_{CC}^2/8R_L}{V_{CC}^2/2R_L}\times 100 = 25\%}$$

P_C = Power dissipated in the BJT

$$= \frac{1}{T}\int_0^T v_{CE}\, i_C\, dt$$

$$= \frac{1}{T}\int_0^T [V_{CC} - i_C R_L]\, i_C\, dt$$

$$= \frac{1}{T}\int_0^T V_{CC}\, i_C\, dt - \frac{1}{T}\int_0^T i_C^2 R_L\, dt$$

$$= \frac{1}{T}\int_0^T V_{CC}(I_{CQ} + i_c)\, dt - \frac{1}{T}\int_0^T [I_{CQ} + i_c]^2 R_L\, dt$$

$$= V_{CC}\cdot I_{CQ} - I_{CQ}^2 R_L - \frac{1}{T}\int_0^T i_c^2 R_L\, dt$$

$$P_C = \frac{V_{CC}^2}{2R_L} - \frac{V_{CC}^2}{4R_L} - \frac{1}{2} I_{m}^2\cdot R_L$$

$$\therefore \boxed{P_C = \frac{V_{CC}^2}{4R_L} - \frac{1}{2} I_{Lm}^2 R_L} \quad \text{---} \quad (5)$$

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P_c will be maxm when $I_{Lm} = 0$.

$$\therefore (P_c)_{maxm.} = \frac{V_{cc}^2}{4R_L}.$$

$$\text{Figure of merit} = \frac{(P_c)_{max.}}{(P_{L,ac})_{max.}} = \frac{V_{cc}^2/4R_L}{V_{cc}^2/8R_L} = 2$$

Disadvantage

<1> $\eta_{max} = 25\%$

<2> High Figure of merit

<3> Power consumption by the transistor is maxm. when the i/p is zero.

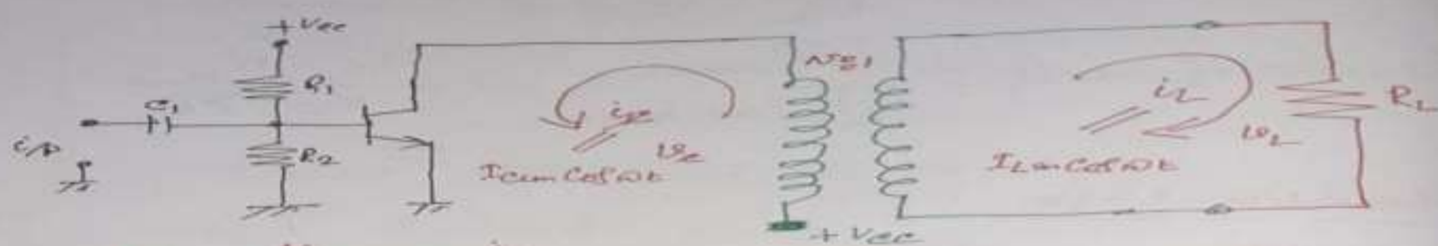
Advantage.

This is the linear amplifier i.e o/p $\propto$ i/p.

* The disadvantages are acceptable for small signal transistor amplifier, but for large signal improvements are necessary. For large signal amplifier this is known as Class A Amplifier.

Power Amplifier

Transformer Coupled Class A Amplifier



$$n = \frac{v_c}{v_L} = \frac{i_L}{i_c}$$

$$R_L = \frac{v_L}{i_L} = \frac{v_c/n}{n\, i_c} = \frac{1}{n^2}\underbrace{\left(\frac{v_c}{i_c}\right)}_{R_L'}$$

(Reflected impedance)

$$\boxed{R_L' = n^2 R_L}$$

$$P_{cc} = \text{Power Supplied} = V_{cc}\cdot I_{CQ} = V_{cc}\cdot\frac{V_{cc}}{R_L'} = \frac{V_{cc}^2}{R_L'} \quad \cdots (1)$$

$$P_{L,ac} = \text{Load Power Dissipation} = \frac{1}{2} I_{Lm}^2 R_L$$

$$= \frac{1}{2} I_{cm}^2 R_L' \quad \cdots (2)$$

$$(P_{L,ac})_{max} = \frac{V_{cc}^2}{2R_L'} \quad \cdots (3)$$

$$\eta_{max} = \frac{V_{cc}^2/2R_L'}{V_{cc}^2/R_L'} \times 100 = 50\%$$

Improvement

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$$P_c = \frac{V_{cc}^2}{R_L'} - \frac{1}{2} I_{Lm}^2 \cdot R_L.$$

$$(P_c)_{max} = \frac{V_{cc}^2}{R_L'} \quad - - - - (4)$$

maxm. power is consumed by the transistor when the i/p is zero — no improvement

$$\text{figure of merit} = \frac{(P_c)_{maxm.}}{(P_{L,ac})_{maxm.}}$$

$$= \frac{V_{cc}^2/R_L'}{V_{cc}^2/2R_L'} = 2$$ no improvement

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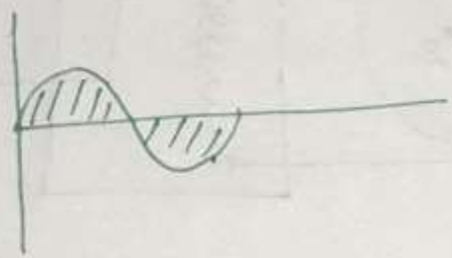
Since Power consumed by the BJT is high, [moreover it is unwanted thus known as Conduction Loss]

Here transistor is always on



Conduction Range = 0 to 360°

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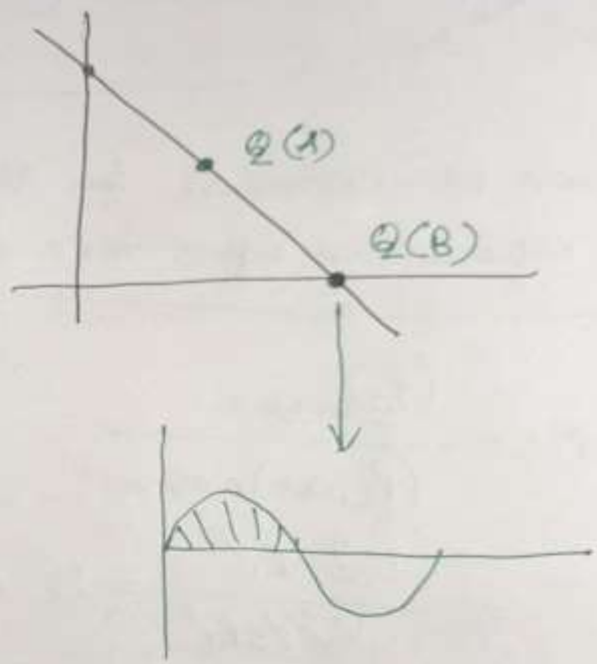
In order to reduce P_c ie conduction loss let us reduce conduction time or conduction angle of transistor



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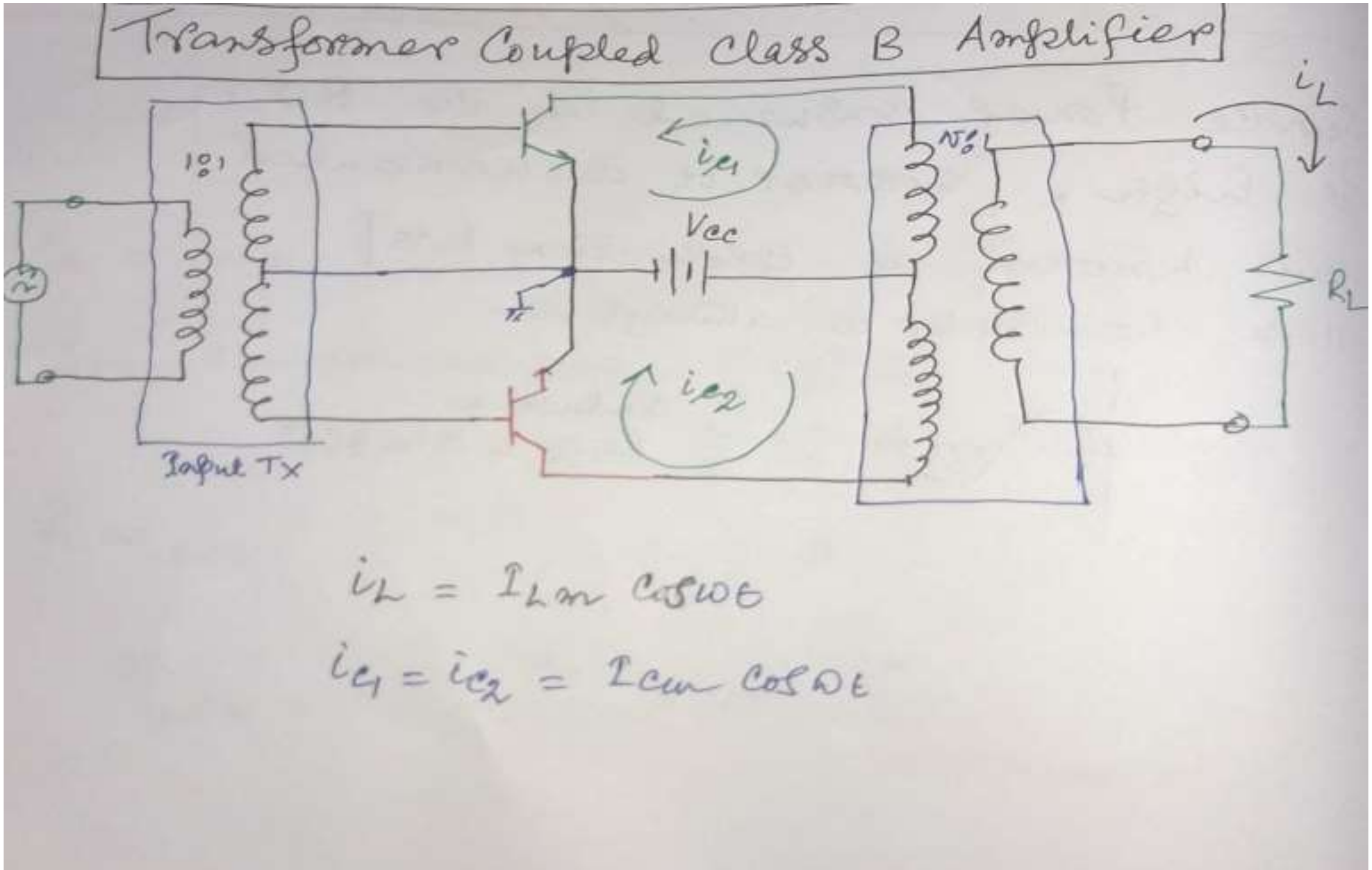

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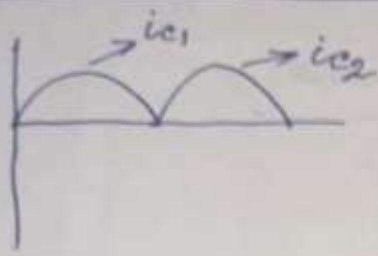
Current characteristics.



$$I_{c,av} = \frac{2I_{cm}}{\pi}$$

P_{cc} = Power Supplied to the Amplifier

$$= V_{cc} \cdot I_c = V_{cc} \cdot \frac{2I_{cm}}{\pi} \quad \text{.....} \; (1)$$

$$(P_{cc})_{max} = V_{cc} \cdot \frac{2V_{cc}}{\pi R_L'} \qquad \left[\begin{aligned} I_{cm} &= I_{CQ} \\ &= \frac{V_{cc}}{R_L'} \end{aligned} \right]$$

$$\boxed{(P_{cc})_{max} = \frac{2V_{cc}^2}{\pi R_L'}} \quad \text{...} \; (2)$$

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$$(P_{L,ac}) = \frac{1}{2} I_{Lm}^2 R_L$$

$$= \frac{1}{2} I_{cm}^2 R_L'$$

$$(P_{L,ac})_{max} = \frac{1}{2} \cdot \frac{V_{cc}^2}{R_L'^2} \cdot R_L' = \frac{V_{cc}^2}{2R_L'} \quad \cdots \text{(3)}$$

$$\eta_{max} = \frac{(P_{L,ac})_{max}}{(P_{cc})_{max}} \times 100 = \frac{V_{cc}^2/2R_L'}{2V_{cc}^2/\pi R_L'} \times 100$$

$$= \frac{\pi}{4} \times 100$$

$$= 78.5\%$$ Improvement

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$$P_c = \frac{2V_{cc}I_{cm}}{\pi} - \frac{1}{2}I_{cm}^2 R_L'$$

Use th. of maxima condition

$$\frac{dP_c}{dI_{cm}} = 0 = \frac{2V_{cc}}{\pi} - I_{cm}R_L'$$

$$\therefore \quad I_{cm} = \frac{2V_{cc}}{\pi R_L'}$$

$$\therefore (P_c) = \frac{2V_{cc}}{\pi}\cdot\frac{2V_{cc}}{\pi R_L'} - \frac{1}{2}\cdot\frac{4V_{cc}^2}{\pi^2 R_L'^2}\cdot R_L'$$

$$= \frac{4V_{cc}^2}{\pi^2 R_L'} - \frac{2V_{cc}^2}{\pi^2 R_L'}$$

$$(P_c)_{max} = \frac{2V_{cc}^2}{\pi^2 R_L'}$$

$$\text{Figure of merit} = \frac{(P_c)_{max}}{(P_{L,ac})_{max}} = \frac{2V_{cc}^2/\pi^2 R_L'}{V_{cc}^2/2R_L'}$$

$$= \frac{4}{\pi^2} \simeq \frac{2}{5}$$ Improvement

When i/p $= 0$, $I_{cm} = 0$.

So $P_c = 0$ - - - Improvement.

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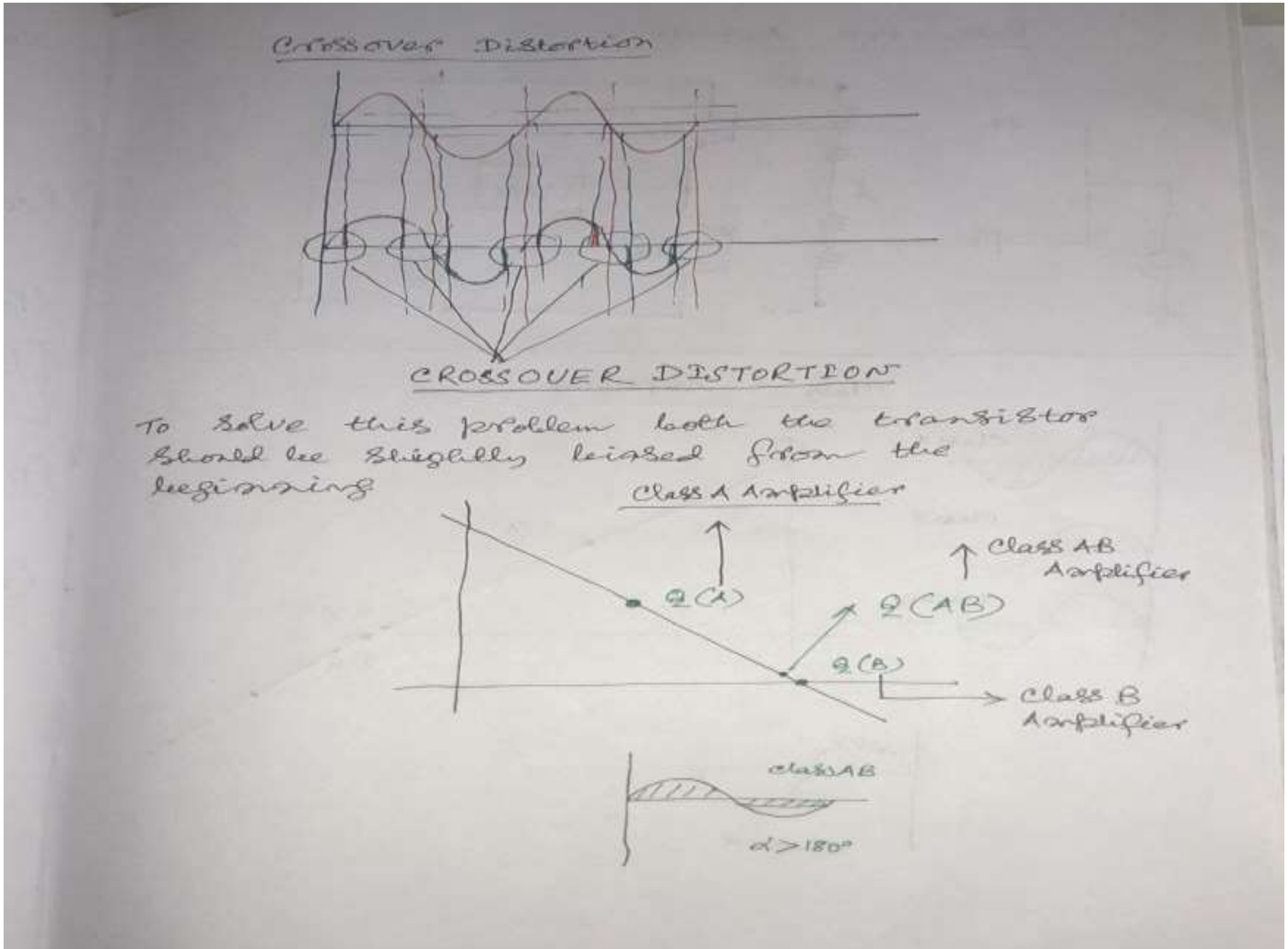

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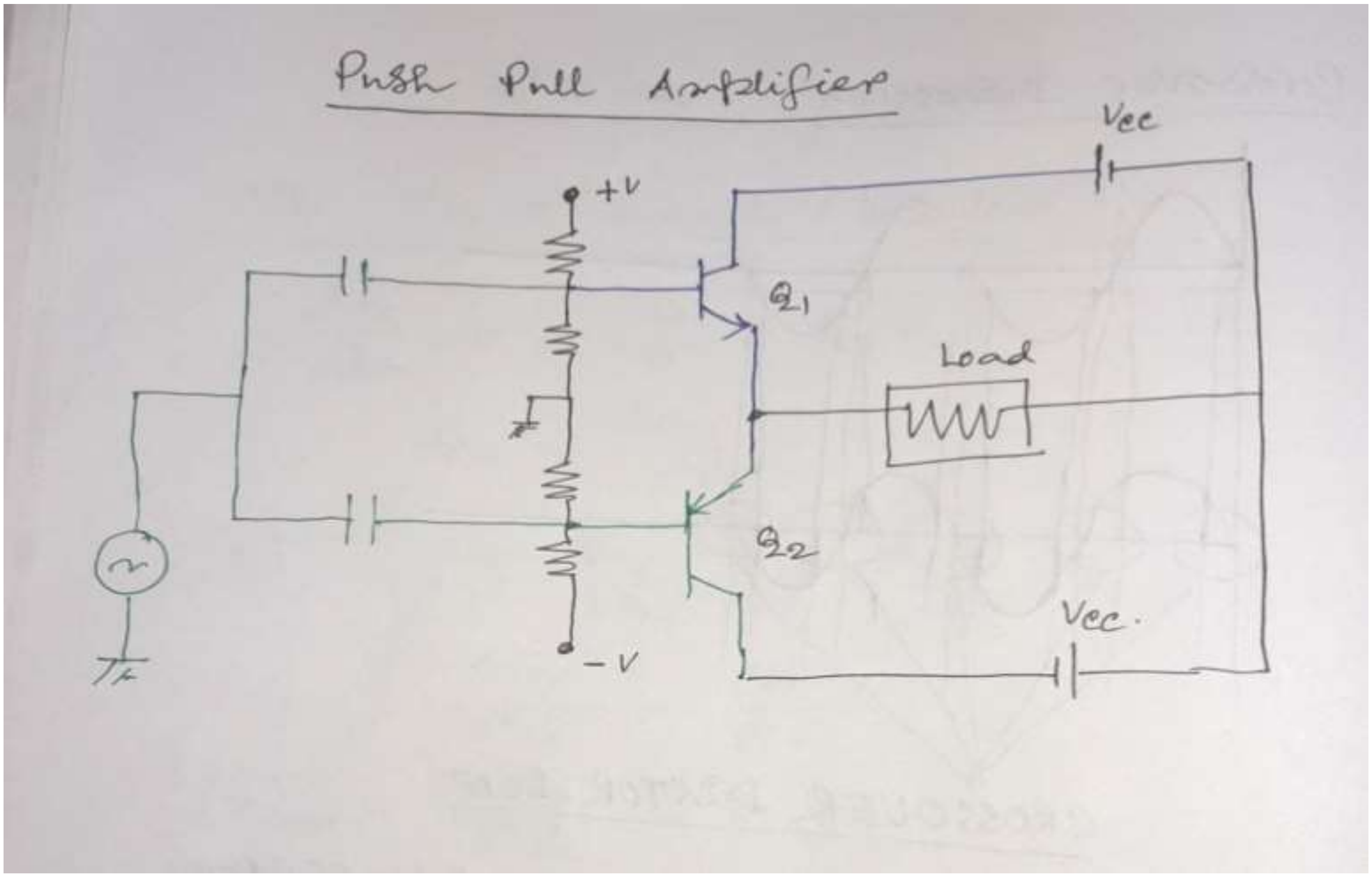

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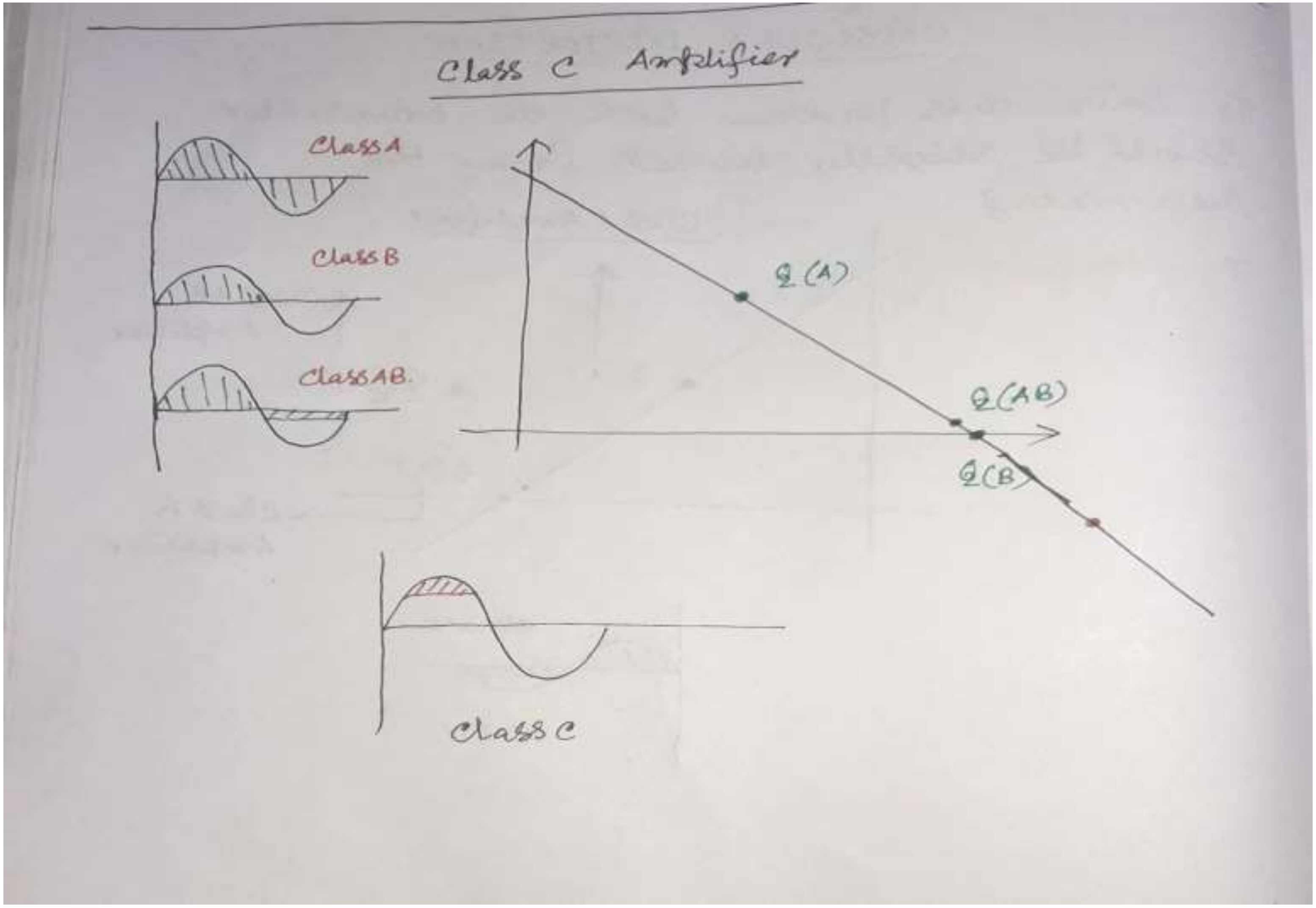

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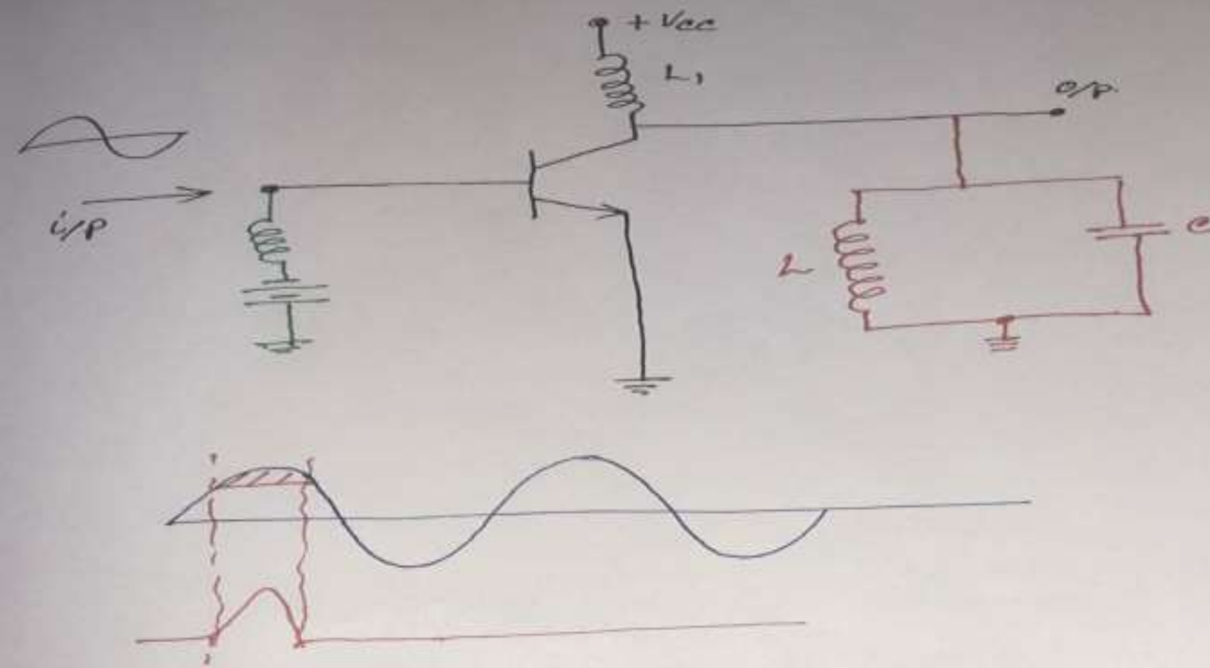

$$\boxed{L\frac{di}{dt} + \frac{1}{C}\int i\,dt = V}$$

Solve & findout the solution