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Internal Assesment Test - II

Sub:	Electronic Principles and Circuits							Code:	BEC303
Date:	14/12/2024	Duration:	90 mins	Max Marks:	50	Sem:	3rd	Branch:	ECE

Answer Any FIVE FULL Questions

		Marks	OBE	
			CO	RBT
1.	(a) Explain the working of RC phase shift oscillator. Use necessary diagrams. (b) Explain the circuit diagram and working of crystal oscillator.	[6+4]	CO3	L2
2.	Explain the working of Astable multivibrator using 555 timer with internal diagram and relevant waveforms.	[10]	CO3	L2
3.	Explain the operation of the first order stages for both LPF and HPF active filters.	[10]	CO4	L2
4.	Explain different types of negative feedback amplifier. Use necessary diagrams.	[10]	CO3	L2
5.	(a) Explain the operation of Class B push pull emitter follower circuit. (b) Differentiate class A, class B, and class C power amplifier.	[6+4]	CO4	L2

P.T.O

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P.T.O

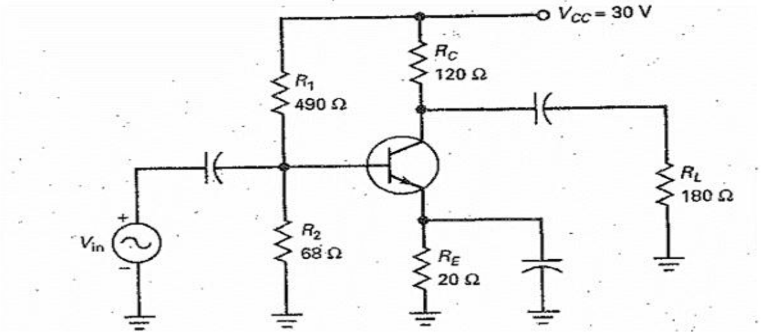
<table>
<tr><td>6.</td><td>Draw the dc and ac load line of the following class A power amplifier.


Fig 1</td><td>[10]</td><td>CO4</td><td>L3</td></tr>
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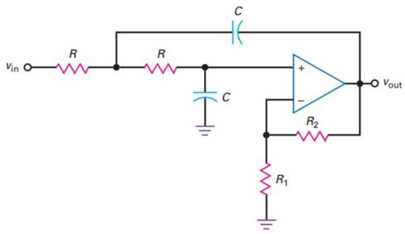

Fig 2
(b)Discuss the advantages and applications of bidirectional thyristors (triacs).</td><td>[6+4]</td><td>CO4</td><td>L3</td></tr>
</table>

CI CCI HOD

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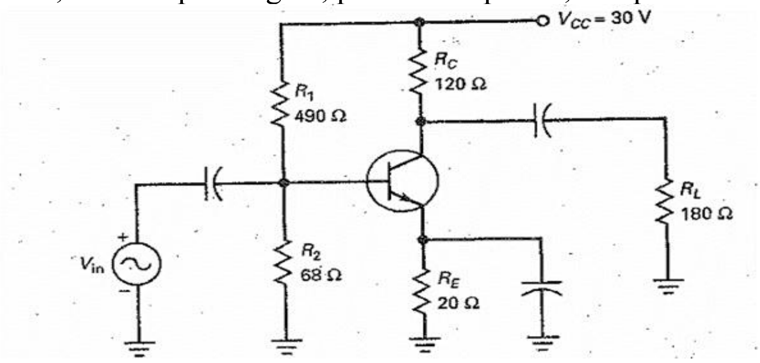

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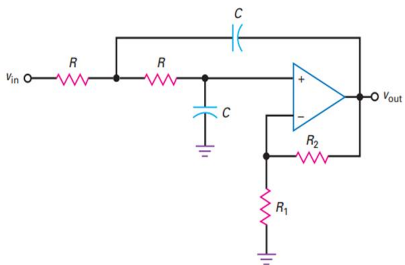

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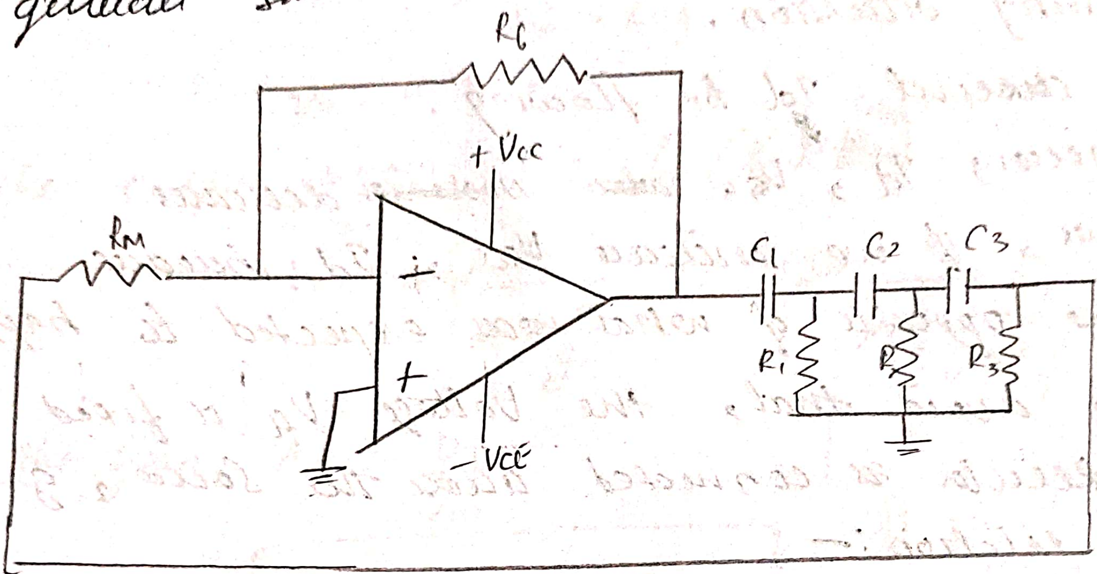
IAT-2

1) a) RC Phase shift Oscillator

The RC phase shift oscillator is a device that generates sine wave signals



> It consists of two networks - the RC filter network and the inverting amplifier network

> In the amplifier, ~~the~~ non inverting terminal is grounded.

> The inverting terminal receives two feedbacks, one from the OPAMP and one from the RC network.

> In the RC network, R and C elements are connected parallely to each other and all the resistors are grounded.

> The inverting OPAMP produces a phase shift of 180°. with respect to input.

> In the RC network, the phase shift across each RC unit can be calculated using

$$\phi = \tan^{-1}\left(\frac{X_C}{R}\right).$$

> Ideally ϕ is 90°, but practically there is a phase

shift of 60°

> Each RC unit provides 60° phase shift and as a result the total phase shift provided by the RC network is 180°.

> Hence the total phase shift within the oscillator is 0° (or) 360°

> Here, the oscillator does not receive any external input but the output is taken as feedback and given to the input.

> It is also important to note that all capacitor and resistor values will be same.

Formulas :
$$f = \frac{1}{2\pi\sqrt{RC}}$$

$$X_C = \frac{1}{2\pi f C}$$

> It can be observed that, the R and C play most vital role in designing the circuit to give a preferred frequency.

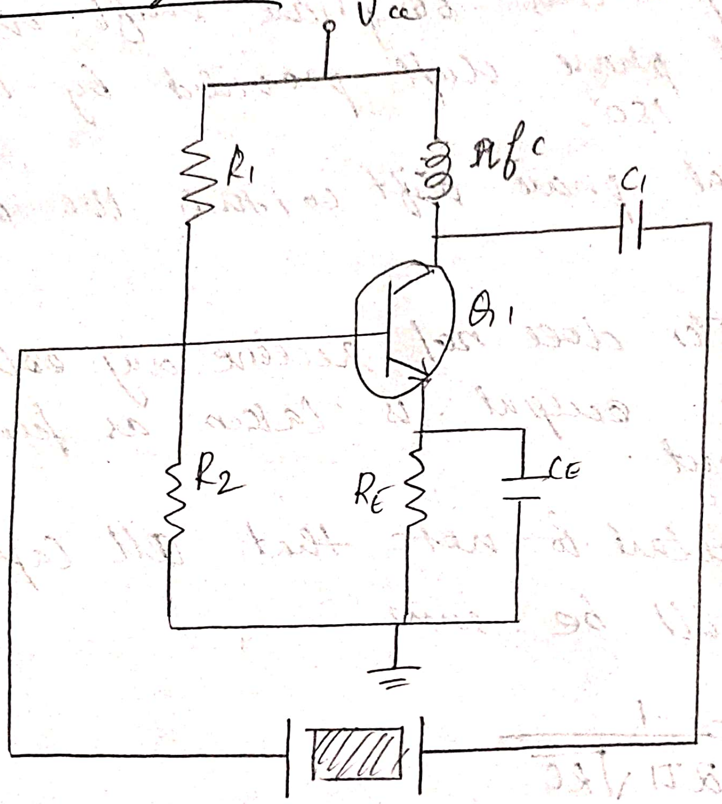
---

b) > Crystal oscillator works on the principle of Piezo-electric effect.

> According to that, when a mechanical stress is applied across any one of the face of the crystal, a potential difference is experienced across other opposite faces and vice versa.

> Quartz is the most commonly used crystal due to its inexpensiveness and easy availability is

Circuit diagram



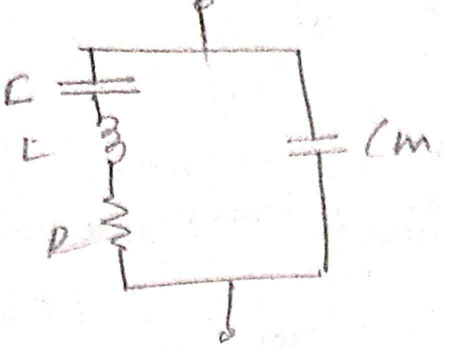
> The crystal oscillator is a voltage divide bias circuit. Vcc is provided at the collector end.
> The Emitter end is connected to Emitter Resistor.
> The Capacitor at the Emitter end ensures that only AC signals pass and is open during DC analysis.

> The Quartz crystal is connected in series from the Collector to the Base.

Working

> When an input Voltage is provided, the crystal experiences a mechanical stress
> If the frequency of the input voltage becomes equal to the natural frequency of the crystal and it experiences Resonance and provides maximum vibrations

The equivalent circuit of the crystal is :-

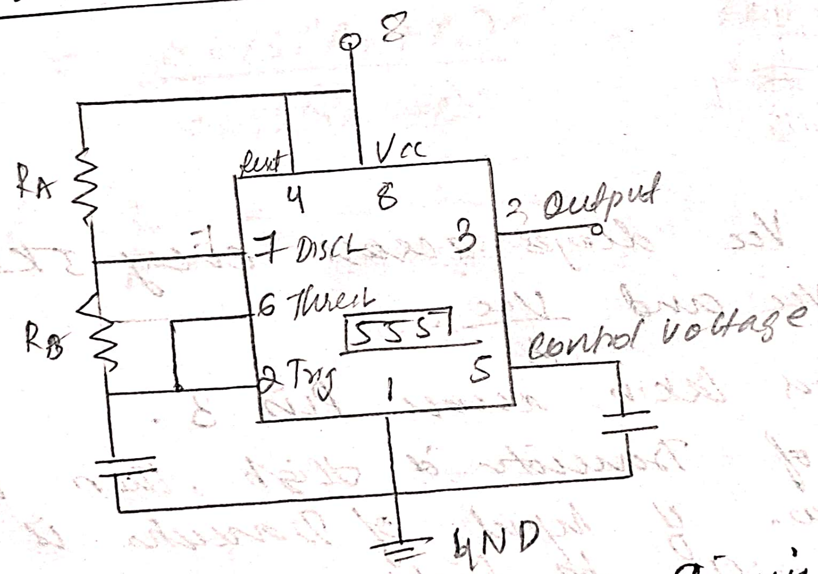


The frequency is $f = \frac{1}{2\pi\sqrt{L C_{TH}}}$

$$C_{TH} = \frac{C \times C_m}{C + C_m}$$

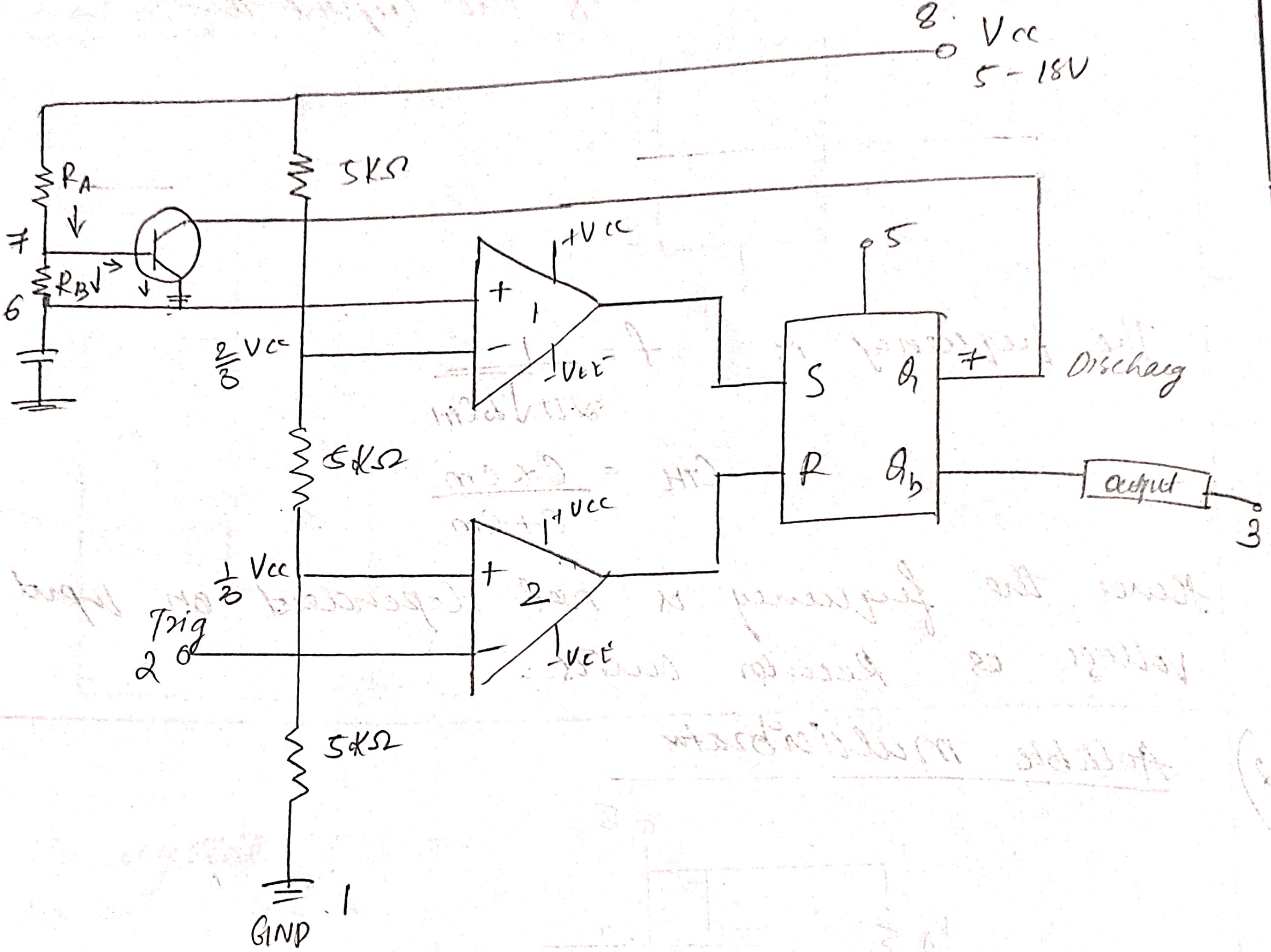
Hence the frequency is not dependent on input voltage or resistor circuits.

2) Astable multivibrator



> An Astable multivibrator is a Timing circuit that does not have any fixed (or) stable state between high and low level.
> It keeps fluctuating
> It doesnt require a Trigger pin to control its working

Internal diagram



> Here, the Vcc drops across every 5KΩ and becomes $\frac{2}{3}$ Vcc and $\frac{Vcc}{3}$.
> The output is taken across Pin 3.
> If input of Transistor is High, then its output will be Low. If Input of Transistor is Low, then ~~its output will~~ be high.
> If Trigger voltage is less than $\frac{Vcc}{3}$ then Comparator 2's output will be high.
> If Threshold Voltage is higher than $\frac{2}{3}$Vcc, then Comparator 1's output will be high.

> Based on this mechanism, SR flip flop is controlled and a definite and accurate timing signal is generated.

> This allows the multivibrator to produce delays from microseconds to few hours.

Formula

The duty cycle is the ratio of time in which the timer was ON to the total time of the cycle.

$$D = \frac{W}{T}$$

The charging time of capacitor is, $T_C = 0.693(R_A + R_B)C$.

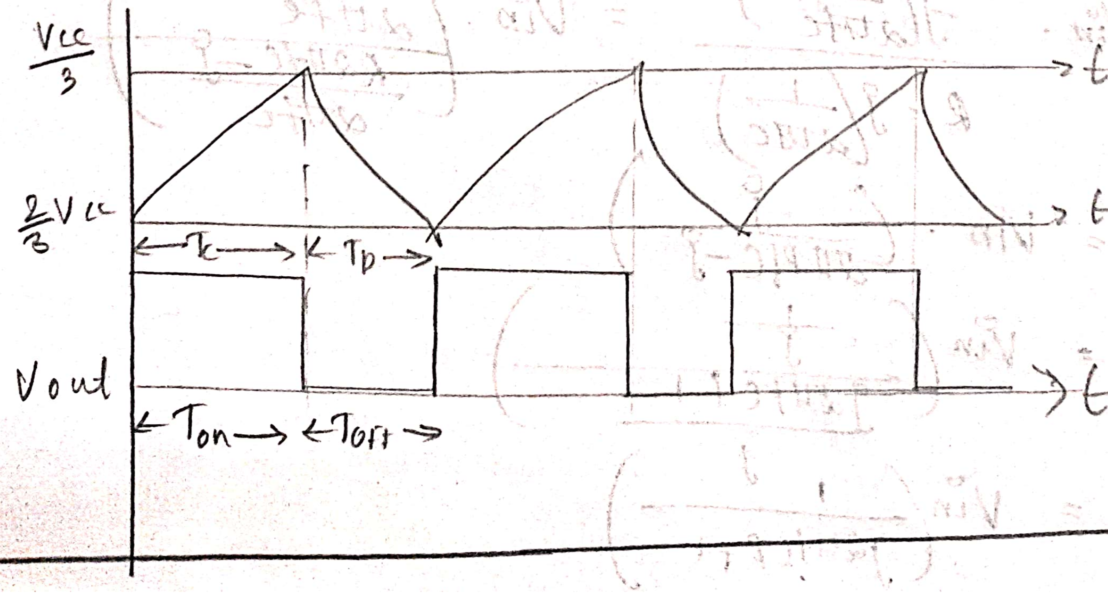
The discharge time of capacitor is, $T_D = 0.693 R_B C$.

Total time, $T = T_C + T_D = 0.693(R_A + 2R_B)C$.

$$\therefore D = \frac{W}{T} = \frac{0.693(R_A + R_B)C}{0.693(R_A + 2R_B)C} = \frac{R_A + R_B}{R_A + 2R_B}$$

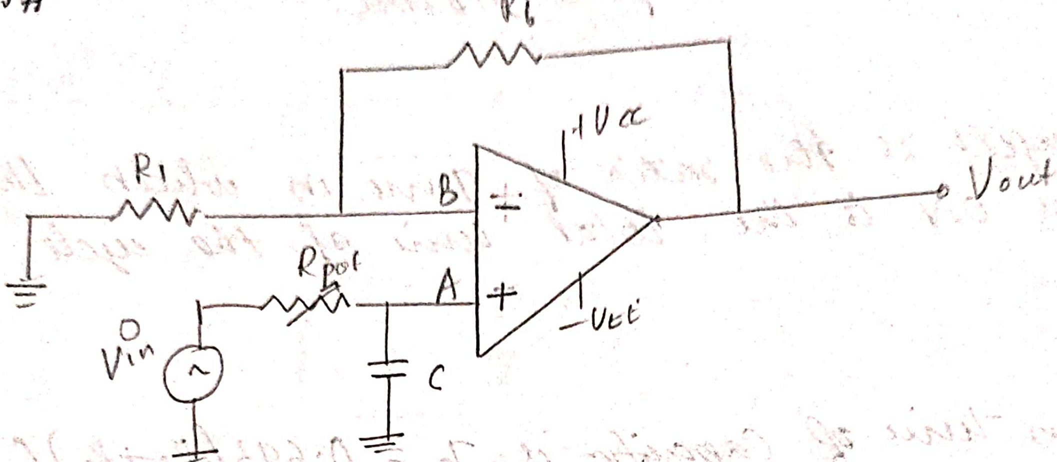
$$\text{Frequency, } f = \frac{1}{T} = \frac{1}{0.693(R_A + R_C)C}$$

Waveform



3) Low Pass butterworth Filter (First Order)

It is a type of filter that produce a low gain in the range of 0 to high cutoff frequency f_H.



Here, the range 0 to f_H is called pass Band and $f > f_H$ is called stop Band.

Impedence across Capacitance, $C = -jX_C$

where $X_C = \frac{1}{2\pi fC}$

The voltage at A is given by voltage divider equation

i.e. $V_A = \frac{V_{in}(-jX_C)}{R - jX_C}$

$\therefore V_A = V_{in} \cdot \frac{-j\left(\frac{1}{2\pi fC}\right)}{R - j\left(\frac{1}{2\pi fC}\right)} = V_{in} \cdot \left(\frac{\frac{-j}{2\pi fC}}{\frac{R2\pi fC - j}{2\pi fC}}\right)$

$V_A = V_{in} \cdot \left(\frac{-j}{2\pi RfC - j}\right)$

$= V_{in}\left(\frac{\frac{-j}{-j}}{\frac{j2\pi fC + 1}{-j}}\right)$

$V_A = V_{in}\left(\frac{1}{j2\pi fCR + 1}\right)$

W.K.T

$$A_v = \frac{V_o}{V_{in}}$$

$$\therefore V_o = A_v V_{in} = A_v \left(\frac{1}{2\pi j f C R + 1} \right)$$

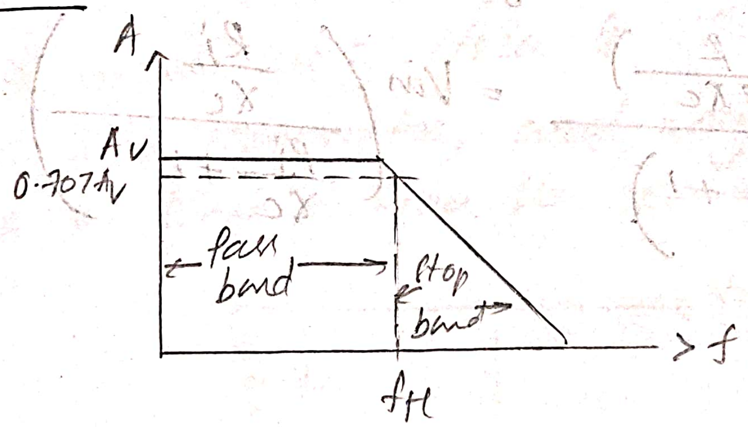
$$V_o = \frac{A_v}{\left(1 + \frac{f}{f_H}\right)}$$

where $A_v = \frac{R_f}{R_1} + 1$

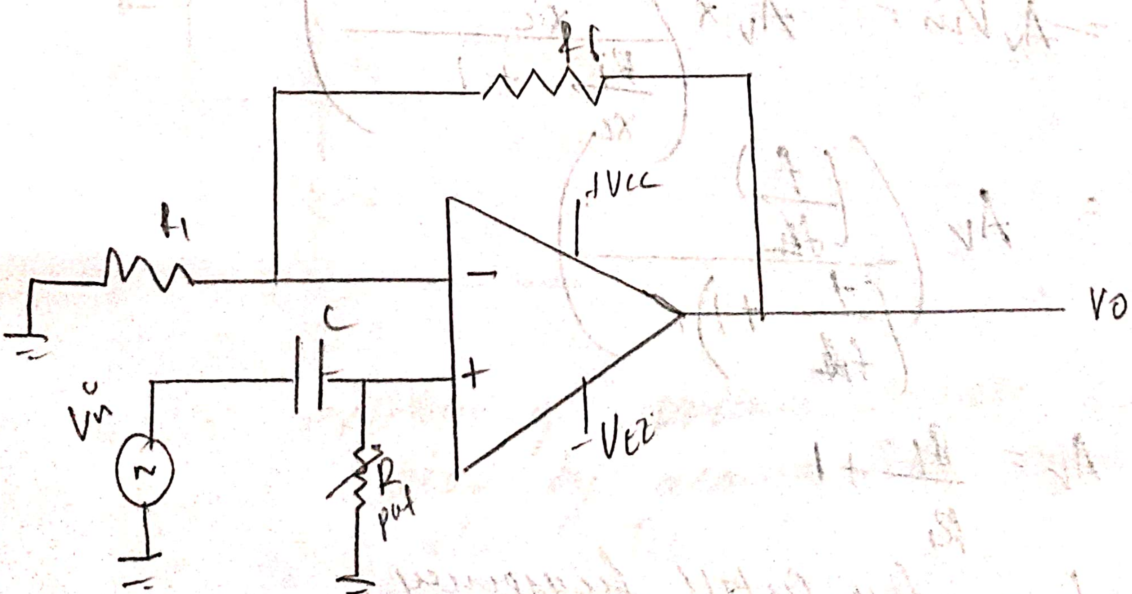
f = Holding frequency

f_H = High cutoff frequency

Waveform



High Pass Butterworth filter (First order)



A High pass filter provides a high gain in the range of 0 to low cutoff frequency f_L.
The range between 0 and f_L is called stop and $f > f_L$ is called pass band.

Impedence across Capacitance, $C = -jX_C = \frac{-j}{2\pi f C}$

Using Voltage division :—

$$V_A = \frac{V_{in}(R)}{R - jX_C} = V_{in}\frac{R}{(-jX_C)\left(\frac{R}{-jX_C}+1\right)}$$

Since $j = \frac{1}{j}$ and $\frac{1}{j} = j$.

$$V_A = V_{in}\frac{\left(\frac{R}{jX_C}\right)}{\left(\frac{R}{jX_C}+1\right)} = V_{in}\left(\frac{\frac{Rj}{X_C}}{\frac{Rj}{X_C}+1}\right)$$

We know that,

Gain $A_V = \frac{V_o}{V_{in}}$

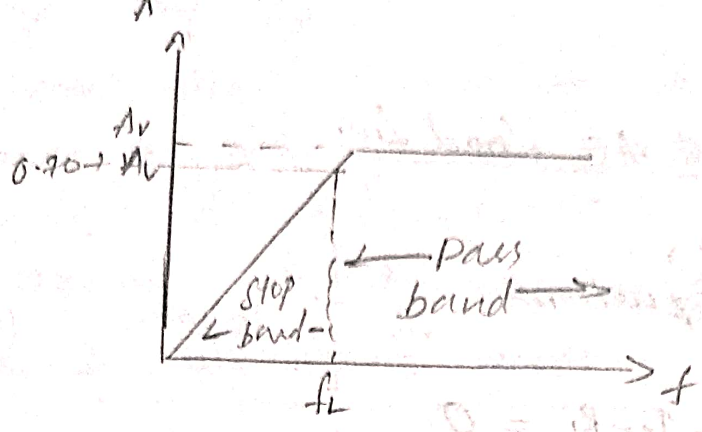
$$V_o = A_V V_{in} = A_V \times \left(\frac{\frac{Rj}{X_C}}{\frac{Rj}{X_C}+1}\right)$$

$$= A_V\left(\frac{\left(\frac{f}{f_L}\right)}{\left(\frac{f}{f_L}+1\right)}\right)$$

where $A_V = \frac{R_f}{R_1} + 1$

f_L = Low cutoff frequency.

Waveform



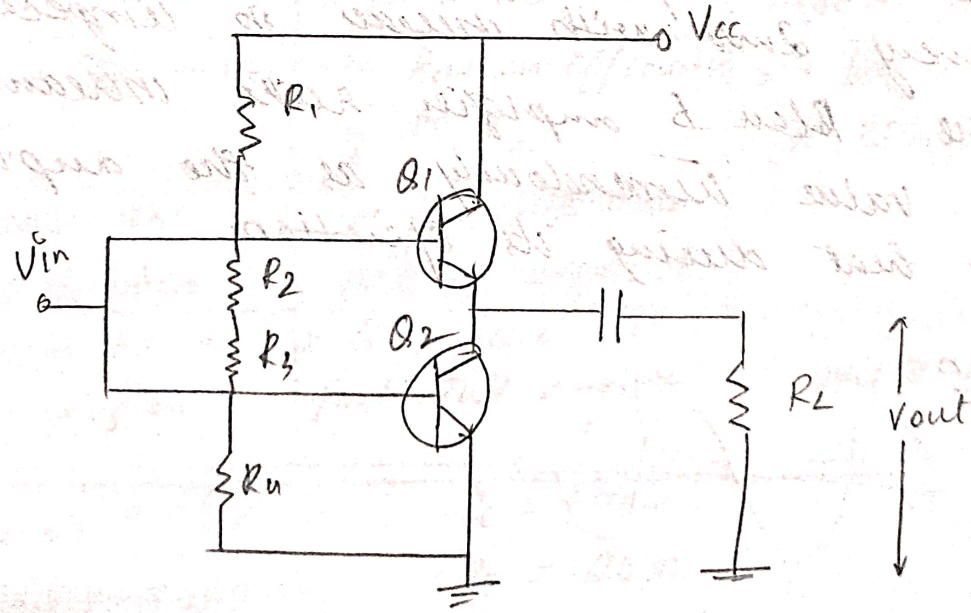
5) a) Class B Push-Pull Emitter follower circuit

A class B amplifier produce output only during half the input cycle

> It has an efficiency of 78.5%.

> Its Q point lies close to the cutoff.

> It uses two Transistors, and only one Transistor is ON at a time - hence the name Push-Pull.



> Due to the existence of voltage divider circuit, each transistor is biased by around 0.6V making I_{CEO} same the ideal value, $I_{CE} = 0$.

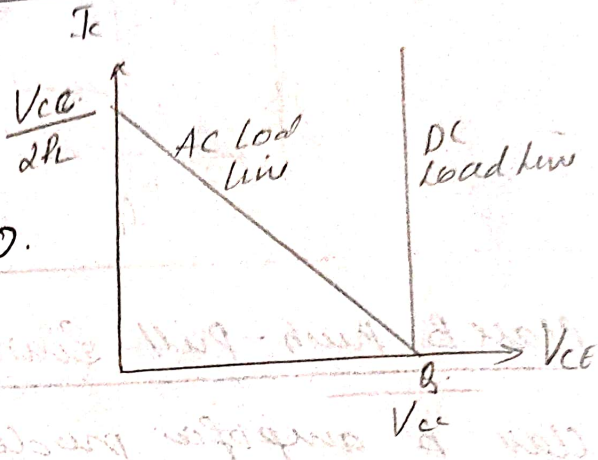
> Since both the Transistors receive same voltage

(as resistors have the same value), then

$$V_{CEQ} = \frac{V_{CC}}{2}.$$

DC load line and AC load line

From the diagram,
we obtain the equation:-



$$V_{CC} - V_{CEQ} - V_{CEQ} - I_{CE} R_L = 0.$$

$$V_{CC} - 2V_{CEQ} - I_{CE} R_L = 0.$$

~~If $V_{CEQ} = \frac{V_{CC}}{2}$~~

If $I_C = 0$,

then $V_{CC} = 2V_{CEQ}$

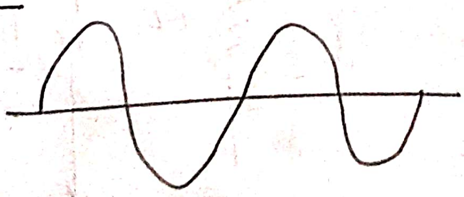
$$\boxed{V_{CEQ} = \frac{V_{CC}}{2}}$$

~~But~~ . ~~V_{CEQ}~~ :

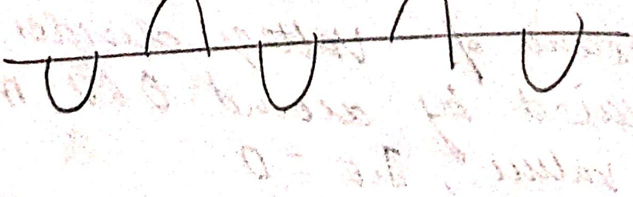
Since the barrier potential across a Si diode drops every 2mV with increase in temperature by 1°C, the Class B amplifier risks increasing the Q point value tremendously as the amplifier produces heat during its operation.

Distortion

Input:



Output:



This distortion arises due to clipping of wave at every half cycle.
Lets assume that there is no biasing, then V_{in} needs to overcome 0.7 V across the Q_1 (i.e $V_{in} > 0.7V$) to be conducted and it needs to more negative than -0.7V to be conducted across Q_2
As a result, distortions arise.

b)

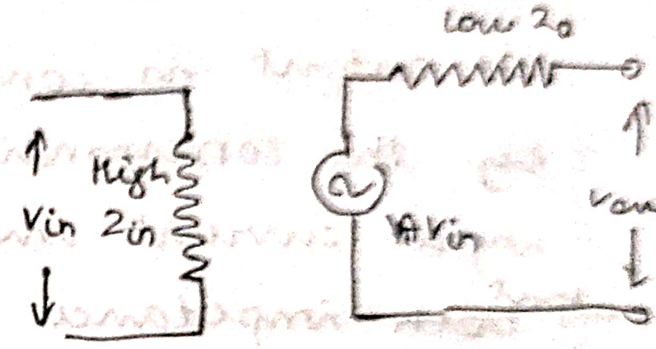
Class A Amplifier	Class B Amplifier	Class C Amplifier
> It produces the output throughout the input cycle	> It produces output for only half the input cycle.	> It produces output for less than half the input cycle.
> Transistor is forward biased for the entire cycle.	> Transistor is forward biased for only half the cycle.	> Transistor is forward biased for less than half the cycle.
> Its conduction angle is 360°	> Its conduction angle is 180°	> Its conduction angle is less than 180°
> It has an efficiency of 50%	> It has an efficiency of 75-8%.	> It has an efficiency of 85-90%.
> It produces less noise and distortions	> It produces more noise as compared	
> It is used as a Power amplifier	> It is used as a Push-Pull amplifier	> It is used in radio receivers.

6)
V_{out} (p-p) = 18V
Z_{in} (base) = 100Ω
V_{in} = 200mV
R_1 = 490Ω
R_2 = 68Ω
R_C = 120Ω
R_E = 20Ω
R_L = 180Ω
V_{CC} = 30V.

4\. NEGATIVE FEEDBACK is used to stabilize gain and thus reduce output impedance and increase input impedance of the power amplifier.

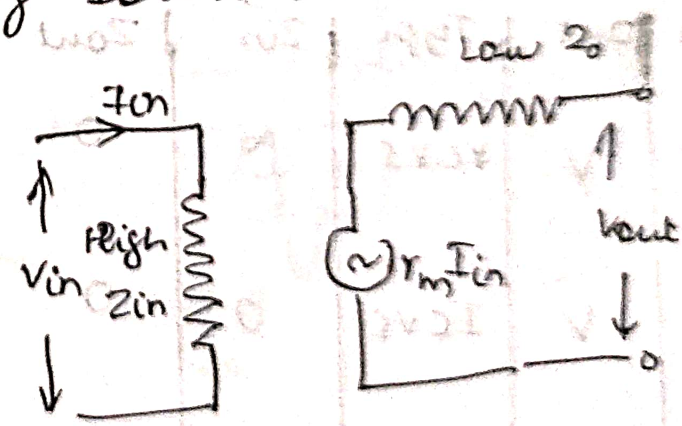
1) voltage controlled voltage source (VCVS)

Here the output voltage is controlled by the input voltage and the amplifier works as a ideal voltage amplifier when Z_{in} is high and Z_{out} is low



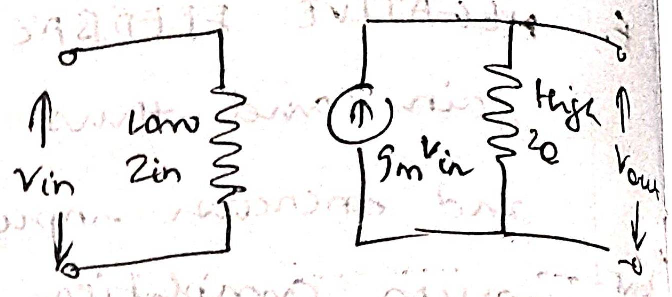
2) current controlled voltage source (ICVS)

Here the output is controlled by change in I_{in} and it is also called transresistance amplifier due to change from i to v.



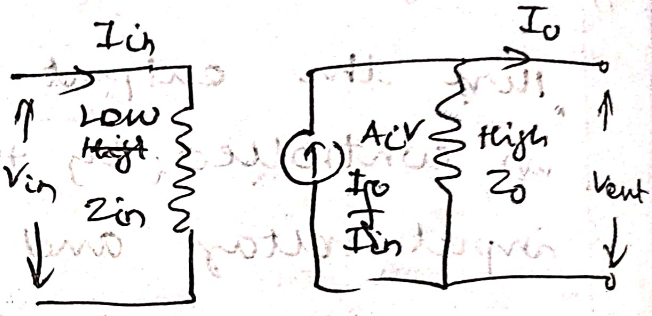
3 Voltage controlled current source

Here the output current is controlled by the corresponding input voltage and it is also called transconductance amplifier



4) current controlled current source (ICIS):

Here the current at output is controlled by the corresponding input current and output ~~both~~ impedances are high and in parallel connection. It is an ideal current amplifier



In	Out	Type	Zin	Zout	converts	Ratio	Amplifier
V	V	VCVS	∞	0	—	$\frac{V_o}{V_{in}} = A_V$	voltage
I	V	ICVS	0	0	i to v	$r_m = \frac{V_o}{I_{in}}$	transresistance
V	I	VCIS	∞	∞	v to i	$g_m = \frac{I_{out}}{V_{in}}$	transconductance
I	I	ICIS	0	∞	—	$A_i = \frac{i_{out}}{i_{in}}$	current

6. $I_{CQ} = 150\,mA$

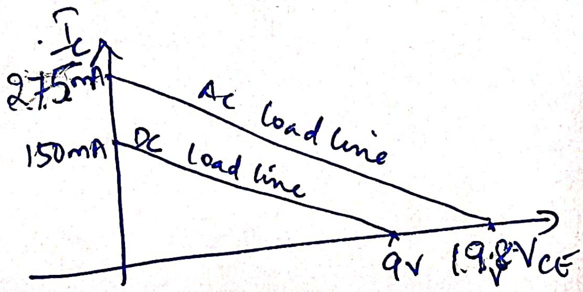
$V_{CEQ} = 9\,V$

$r_e = R_C \| R_L = 120\Omega \| 180\Omega = 72\Omega$

$i_c(sat) = I_{CQ} + \frac{V_{CE}}{r_e} = 150\,mA + \frac{9V}{72\Omega} = 275\,mA$ — (3)

$V_{ce}(cut\ off) = V_{CEQ} + I_{CQ} r_e = 9V + (150mA)(72\Omega)$

$= 19.8\,V$ — (4)



— (3)

— (1)

7(a) $A_v = \frac{33}{33} + 1 = 2$

— (1)

$Q = \frac{1}{3 - A_v} = \frac{1}{3-2} = 1$

$f_p = \frac{1}{2\pi RC} = \frac{1}{2\pi \cdot 75K \cdot 100pF} = 21.27\,KHz$ — (1)

— (1.5)

$f_c = K_c f_p = 21.27\,KHz.$

— (1.5)

$f_{3dB} = K_3 f_p = 27.05\,KHz$

6. $Z_{in\ stage} = 490\Omega \| 68\Omega \| 100\Omega = 37.4\Omega$

$P_{in} = \frac{200mV}{8(37.4)} = 133.7\ \mu W$

$P_{out} = \frac{(18V)^2}{8\cdot(180\Omega)} = 225\ mW$

$A_p = \frac{225}{133.7\ \mu W} = 1683$ — (3)

$I_E = \frac{3V}{20\Omega} = 150\ mA$

$I_{CQ} = 150\ mA$

$V_C = 30V - (150mA)(120\Omega) = 12V$

$V_{CEQ} = 12V - 3V = 9V$

$P_{DQ} = V_{CEQ}\ I_{CQ} = (9V)(150mA) = 1.35\ W$

$I_{bias} = \frac{30V}{490\Omega + 68\Omega} = 53.8\ mA$

$I_{dc} = I_{bias} + I_{CQ} = 53.8\ mA + 150\ mA$ — (3)

$= 203.8\ mA$

$P_{dc} = V_{CC}\ I_{dc} = (30V)(203.8\ mA) = 6.11\ W$ — (2)

$\eta = \frac{225\ mW}{6.11\ W} \times 100\% = 3.68\%$ — (2)