Instructions to the candidates, if any :—

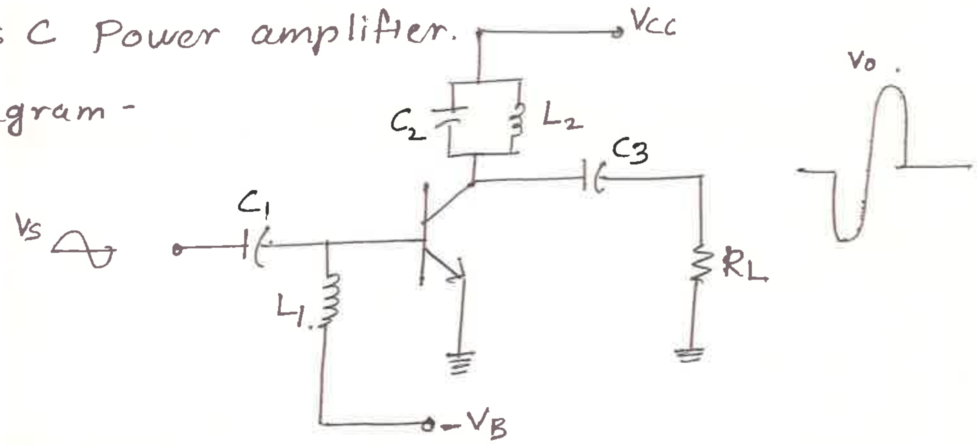
N.B. :

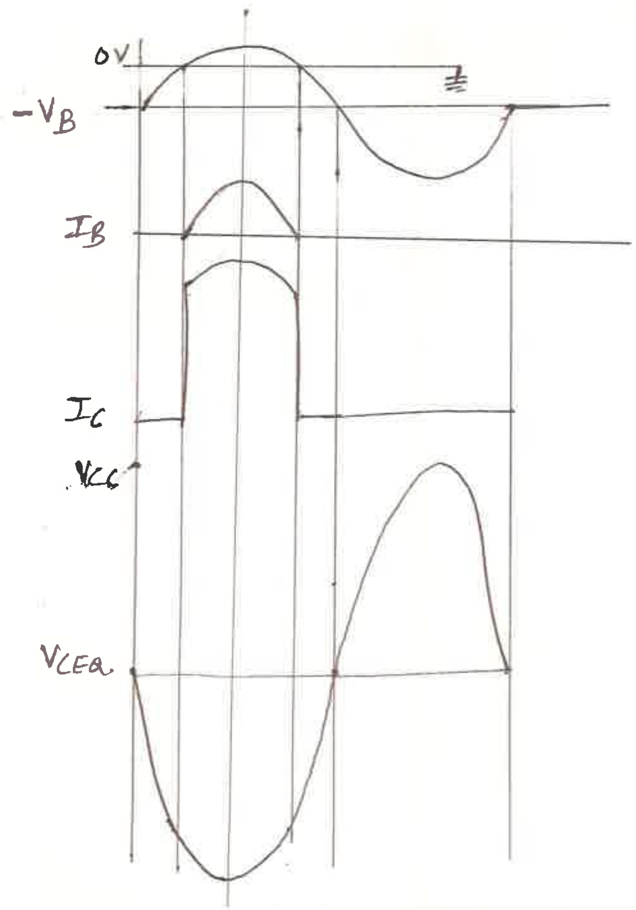
1) Valid Design steps other than given in the solutions can be considered right.
2) Suitable assumptions, ~~suitable~~ valid circuit diagrams, should be considered right.

Q. No.	Marks

Q-1-a. Class C Power amplifier.

Circuit diagram -





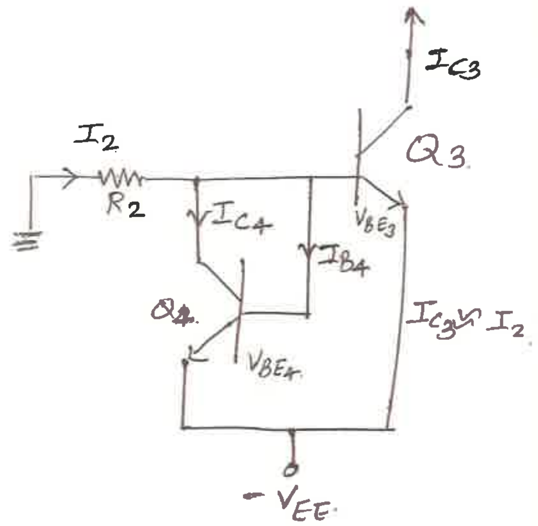
ckt - (01) mark

w/f - (01) mark

expl. - (03) marks.

Q. No. Marks

Q-1-b. Current mirror circuit -



$V_{BE3} = V_{BE4}$, $I_{C3} = I_{C4}$ & $I_{B3} = I_{B4}$

At node A ;

$I_2 = I_{C4} + I = I_{C4} + I_{B3} + I_{B4}$

$= I_{C4} + 2 I_{B4}$

Also $I_2 = I_{C3} + 2 I_{B3}$

$= I_{C3} + 2 \cdot \left(\frac{I_{C3}}{\beta}\right)$

$= I_{C3} \left(1 + \frac{2}{\beta_{dc}}\right)$

Ckt dia - 02

As β is large, 2nd term is neglected

$\therefore \quad I_2 \approx I_{C3} \cong \frac{V_{EE} - V_{BE3}}{R_2}$

Q-1-C.

Voltage Series Conf^n	Voltage shunt Conf^n
1> other name	
2> Block diagram	
3> f/b signal.	
4> Mixing signal	
5> equivalent circuit.	
6> Gain formulas.	
7> comment on impedances	

Block diagram - ② marks.

& Any ~~four~~ three are ~~exp~~ expected.

Marks

Q. No.

Q-1-d. $S.R. = \omega V_{PK}$.

For IC 741

$f_{max} = \frac{S.R}{2\pi V_{PK}}$

$= 7.95 KHz$

$\therefore$ 741 is not suitable.

For IC TL 081

$f_{max} = 206.9 KHz$.

f_{max} of 741. - (2)
of TL081 - (2)
comment - (1)

Q-2-(a) step (1)- selection of power transistor.

$\eta_T = \frac{P_L}{P_L'}$

Assume $\eta = 80\%$ to 90%.
& $P_L = 5W$.

step-(2) $P_{D(max)} = 2 P_L'$

Select Power transistor having $P_{D(max)} >$ required.

step(3) - Calculation of R_E -

$R_E = \frac{V_{RE}}{I_{CQ}} = \frac{15\% V_{cc}}{I_{CQ}}$ & $R_L' = \frac{[V_{CC} - V_{CE(sat)}]^2 \times \eta}{2 \times P_L}$

step (4) - $S = 1 + \frac{R_{th}}{R_E}$

$\therefore \frac{R_{th}}{R_E} = S - 1$

Assume $R_2 <<< R_1 \Rightarrow R_2 \simeq R_{th}$.

$V_{BQ} = V_{R_2} = V_{BE} + V_{RE}$.

$V_{R_2} = V_{cc} \frac{R_2}{R_1 + R_2}$

Calculate R_1 & R_2.

Step (5) - $\frac{N_1}{N_2} = \sqrt{\frac{R_L'}{R_L}}$

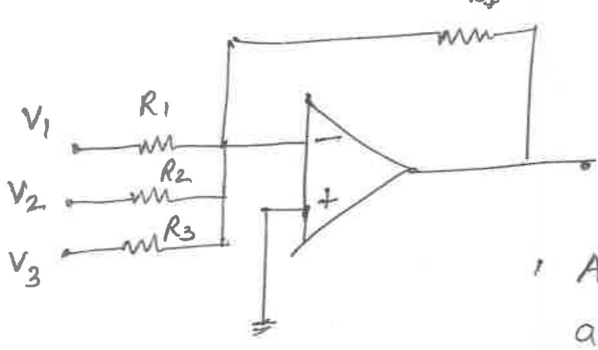
Calculate $N_1 : N_2$

step (8) - $\eta = \frac{P_o(ac)}{P_i(dc)}$

Note η should be less than 50%.
All resistor's power ratings should be calculated.
Diagram with values should be shown in the ans.

Q-2-b. eq^n is $V_o = -2V_1 - 4V_2 - 6V_3$.

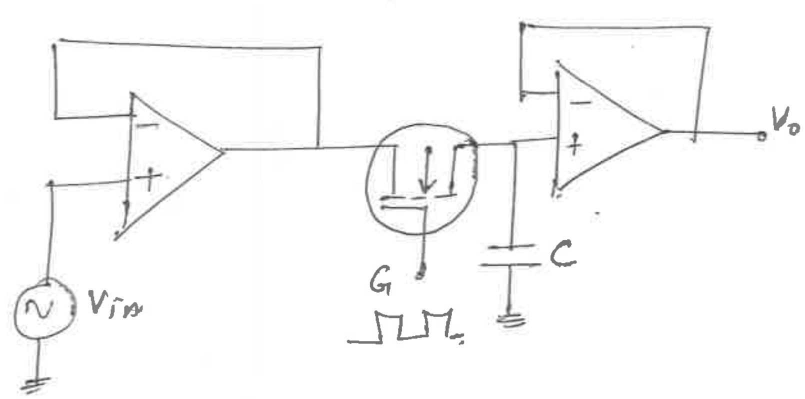
∴ INV adder will be used.



$V_o = \frac{-R_f}{R_1} V_1 - \frac{R_f}{R_2} \cdot V_2 - \frac{R_f}{R_3} V_3$.

, Assume R_f, Calculate R_1, R_2, R_3. accordingly.

Q-2-C. Sample & hold circuit -



06

Q. No. | Marks

$$A_I = \frac{I_o}{I_s} = \frac{-I_{c2}}{I_s}$$

$$= \frac{-I_{c2}}{I_{b2}} \times \frac{I_{b2}}{I_{c1}} \times \frac{I_{c1}}{I_{b1}} \times \frac{I_{b1}}{I_s}$$

$$= h_{fe} \times \frac{I_{b2}}{I_{c1}} \times h_{fe} \times \frac{I_{b1}}{I_s}$$

Now $$\frac{I_{b2}}{I_{c1}} = \frac{h_{fe} \cdot I_{b1} \times \frac{R_{c1}}{R_{c1}+R_{i2}}}{I_{c1}} = \frac{R_{c1}}{R_{c1}+R_{i2}} =$$

& $$\frac{I_{b1}}{I_s} = \frac{I_s \frac{R_s \parallel (R_F+R_e)}{[R_s \parallel (R_F+R_e)]+h_{ie}}}{I_s} = \frac{R_s \parallel (R_F+R_e)}{R_s \parallel (R_F+R_e)+h_{ie}}$$

Now

$$\therefore R_{i2} = h_{ie} + (1+h_{fe})(R_e \parallel R_F)$$

$$= 1k + [(1+50)(50 \parallel 1000)] = 3.42k$$

$$\therefore A_I = h_{fe} \times \left(\frac{3k}{3k+3.42k}\right) \times h_{fe} \times \frac{1k \parallel (1k+50\Omega)}{~~(3k+3.42k)~~ \; [1k \parallel \{(1k+50\Omega)\}+1k]}$$

$$\frac{1000 \times 1050}{1000+1050}$$

$$\frac{1000 \times 1050}{1000+1050} + 1k$$

$$= 50 \times 50 \times 0.467 \times \frac{512.10}{~~513.49~~ \; 1512.2}$$

$$= 395$$

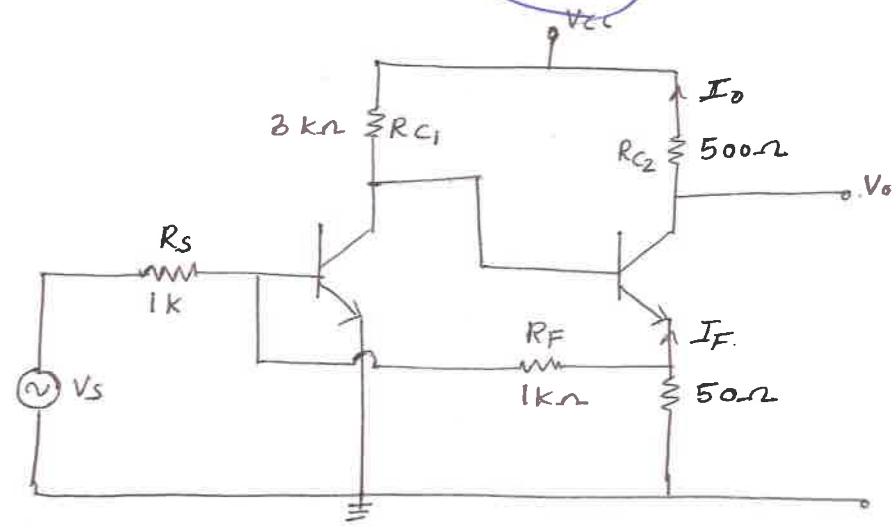
$$D = 1 + B \cdot A_I = 1 + (0.047) \times 395 = 19.565$$

05

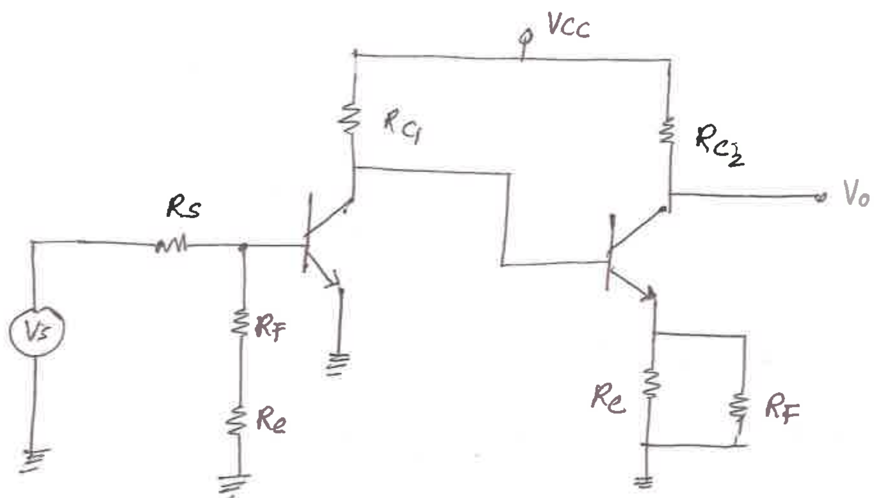
Marks

Q. No.

Q - 3 - A.

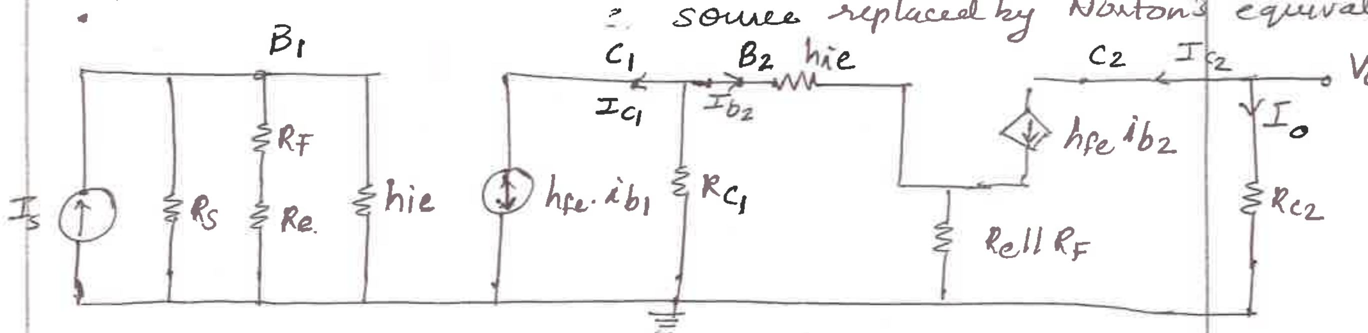


Amplifier without feedback -



Equivalent circuit :- Type - Current shunt (or shunt Series)

∴ source replaced by Norton's equivalent



$$\beta = \frac{I_f}{I_o} = \frac{I_o \cdot \frac{R_e}{R_e + R_F}}{I_o} = \frac{R_e}{R_e + R_F}$$

$$= \frac{50\Omega}{50 + 1k} = 0.047$$

07

Marks

Q. No.

$$A_{IF} = \frac{A_I}{D} = \frac{395}{19.8} = 19.94$$

$$A_{VF} = \frac{V_o}{V_s} = \frac{-I_{C2} \cdot R_{C2}}{I_s \cdot R_s} = \frac{A_{IF} \cdot R_{C2}}{R_s}$$

$$= \frac{19.94 \times 500}{1000}$$

$$= 9.97$$

$$R_i = [R_s \parallel (R_F + R_e)] \parallel h_{ie}$$

$$= [1000 \parallel (1000 + 50)] \parallel 1000$$

$$= 338.7\ \Omega$$

$$R_{iF} = \frac{R_i}{D}$$

$$= \frac{338.7}{19.8}$$

$$= 17.1\ \Omega.$$

0.8

Q. No. | Marks

Q-3-b.

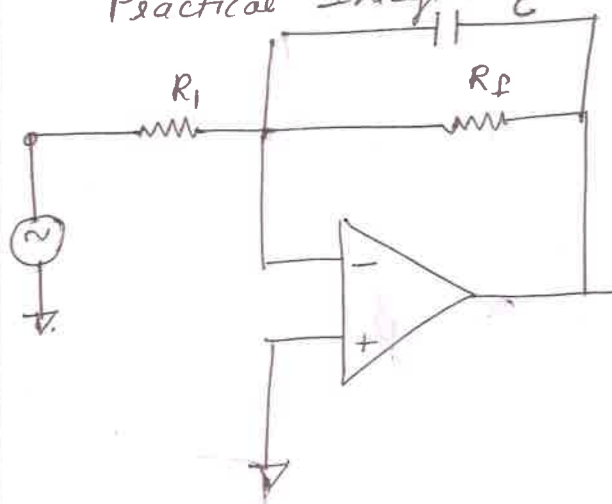
Integrator ckt.

$R_1 = 500\Omega$, $R_f = 5k$, $C = 0.1\,\mu F$.

Period of i/p sig = 0.5 ms.

Find f_a & f_b

Practical Integrator



$$V_o = -\frac{1}{C_F R_1}\int_0^t V_{in}\,dt$$

$$f_a = \frac{1}{2\pi R_f C_f}$$

$$= \frac{1}{2\times\pi\times 5K\times 0.1\times 10^{-6}}$$

$$= \frac{1}{3.14\times 10^{-3}}$$

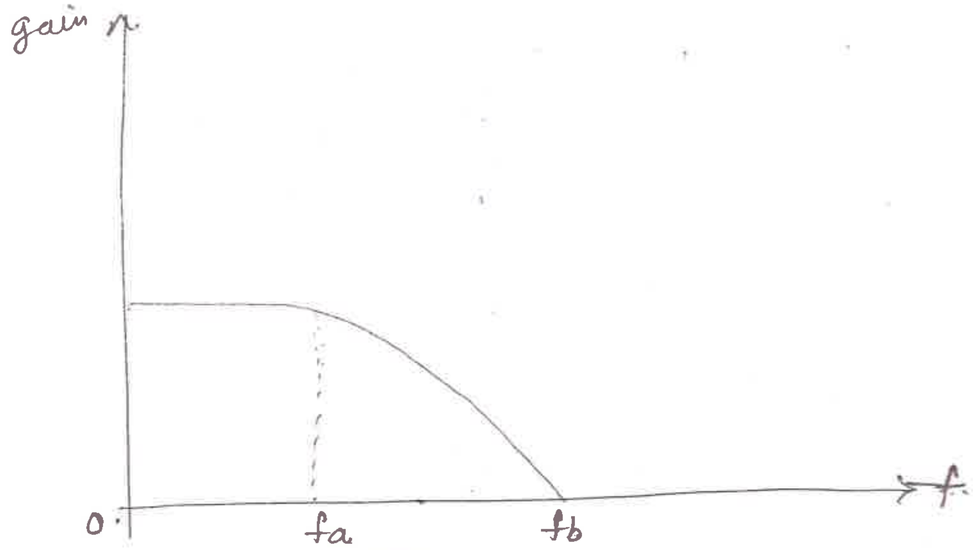
$$= 0.32\ KHz$$

$$f_b = \frac{1}{2\pi R_1 C_F}$$

$$= \frac{1}{2\pi\times 500\times 0.1\times 10^{-6}}$$

$$= \frac{1}{314.15\times 10^{-6}}$$

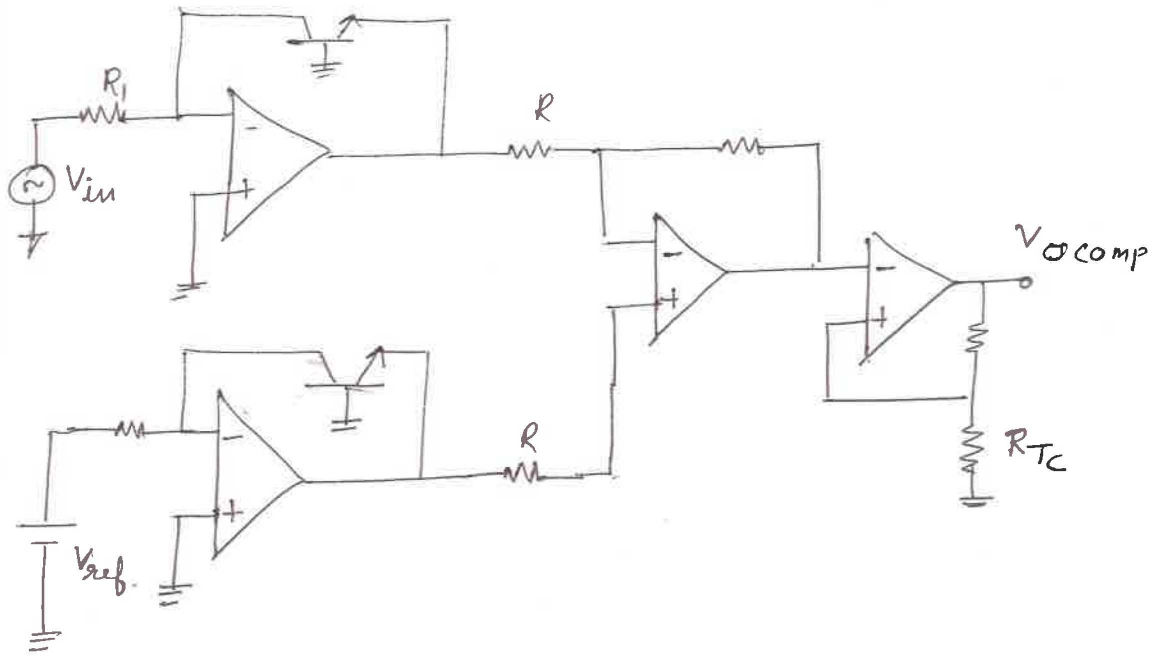
$$= 3.18\ MHz.$$



(09)

Q. No. | | Marks

Q-3-C. Logarithmic amplifier -



$$V_1 = -n V_T \ln \left[\frac{V_{in}}{R_1 I_o} \right]$$

$$V_2 = -n V_T \ln \left[\frac{V_{ref}}{R_1 I_o} \right]$$

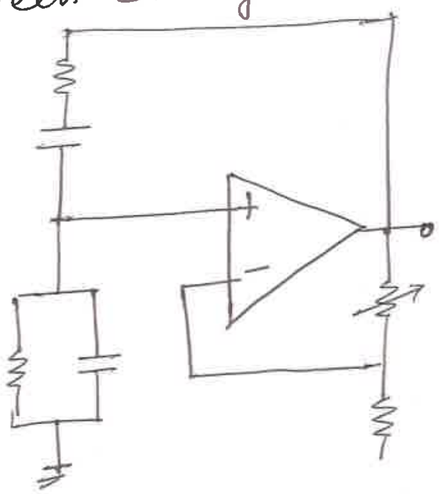
$$\therefore \quad V_o = V_2 - V_1 = n V_T \ln \left[\frac{V_{in}}{V_{ref}} \right]$$

The temp variations are compensated by last-stage op-amp whose gain $= 1 + \frac{R_2}{R_{TC}}$.

Q. No. | Marks

Q-4-(a)

Ween Bridge Osc^{r}



Marks

Diagram - (2)

Explanation - (2)

Derivation for frequency of osc^{r} $= f_o = \frac{1}{2\pi RC}$ - 3

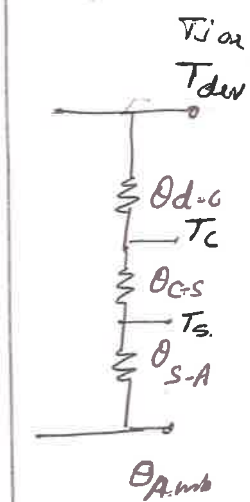
& condition for oscillations $A_v = \frac{1}{\beta}$ - 3

Q-4-(b)

$\theta_{dev\text{-}case} = 1.75°C/W$. $\theta_{case\text{-}sink} = 1°C/W$

$\theta_{sink\text{-}amb} = 5°C/W$ $\theta_{case\text{-}amb} = 50°C/W$

T_A = ambient Temp $= 30°C$, $T_{j(max)} = 120°C$.



$$P_{D(max)} = \frac{T_{j\,max} - T_A}{\theta_{JC} + \theta_{CS} + \theta_{SA}}$$

Considering design for 50W power dissipation

$$50 = \frac{120 - 30}{\theta_{JA(max)}}$$

$$\therefore \theta_{JA(max)} = \frac{90}{50} = 1.8°C/W$$

$$\therefore P_{D(max)} = \frac{T_j - T_A}{\theta_{JA(max)}}$$

But $\theta_{JA(max)} = \theta_{CA} + \theta_{JC} = 50 + 1.75 = 51.75$

$$P_{D(max)} = \frac{120 - 30}{51.75} = 1.73\,W. \text{ (Without heat sink)}$$

Now with heat sink,

$$P_{D(max)} = \frac{T_{J(max)} - T_A}{\theta_{JC} + \theta_{CS} + \theta_{SA}}$$

$$= \frac{90}{1.75 + 1 + 5} = 11.61\,W.$$

Q. No. | Marks

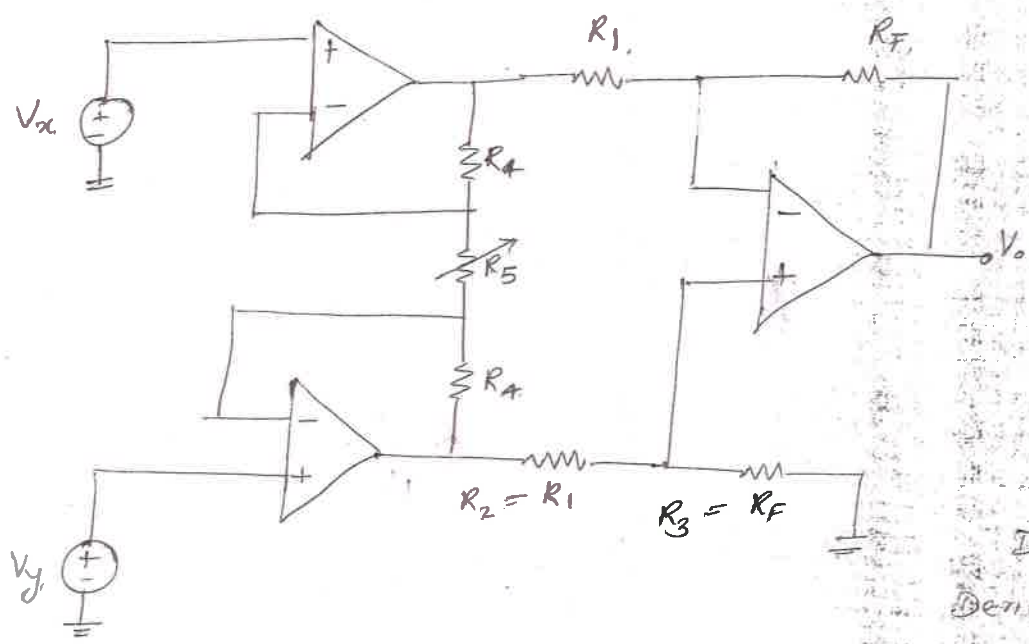
Q-4-C

Advantages of -ve f/b. (Any 5 or if 3 with explaination is accepted)

1> Stabilization of gain -
2> Reduction in frequency distortion
3> Reduction in nonlinear distortion
4> Reduction in noise.
5> Increases bandwidth.
6> Increases input impedance.
7> Reduces output impedance.

Q-5-a

3 op-amp Instrumentation amp^r -



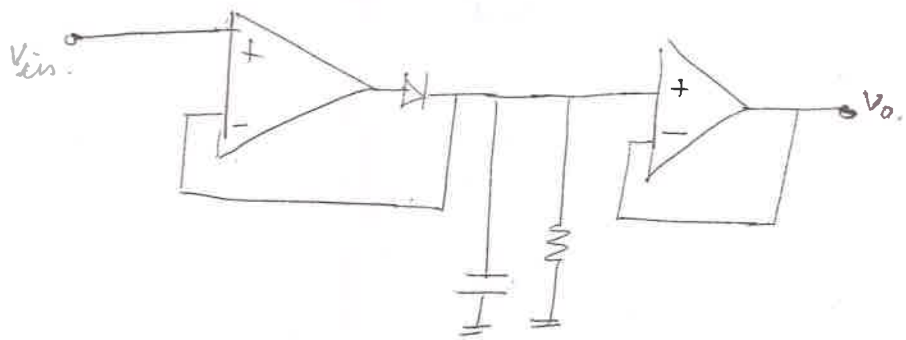
$$A_D = -\left(1 + \frac{2R_4}{R_5}\right)\left(\frac{R_f}{R_1}\right)$$

Dia - (2)
Derivation - (4)
Char / Specification - (3)
Appl^n - (01)

Questions should be —
WRITTEN IN LEGIBLE HANDWRITING IN BLACK INK.
SIGNS, SKETCHES OR FIGURES IF ANY BE DRAWN IN NEAT BLACK INK,
so as to avoid mistakes in the printed question papers.

Duration .... Hours. Total Marks assigned to the paper ....

Q. No.	N.B. :	Marks
Q-5-b	CMRR - Common Mode Rejection Ratio - It is the ability of the op-amp to reject common mode signals.	(01)
	Ideal value = ∞ , Prac = 90 dB.	(01)
	Slew rate - It is the rate of change of o/p voltage w.r.t. time at const i/p volt.	(01)
	Ideal = ∞ Prac 0.5 V/us.	(01)
	I/p offset volt - It is the i/p voltage that should be applied between 2 i/p terminals to null the o/p.	
	Ideal = 0 Prac - 6 mV.	(01)
Q-5-c.	Peak detector circuit - (INV or NINV any conf^n)	

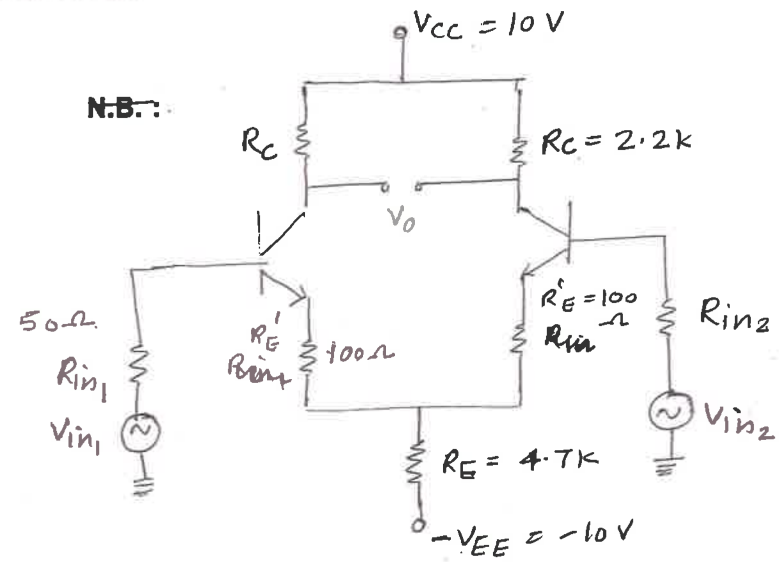


Duration .... Hours. Total Marks assigned to the paper ....

Q. No. Marks

Q-6-a.

N.B. :



$$I_{CQ} = I_E = \frac{V_{EE} - V_{BE}}{2R_E + R_E' + R_{in}/\beta} = \frac{10 - 0.715}{2\times 4.7k + 100 + \frac{50}{100}}$$

$$= 0.977\,mA$$

$$V_{CEQ} = V_{CC} + V_{BE} - I_{CQ} \cdot R_C$$

$$= 10 + 0.715 - 0.977\times 10^{-3} \times 2.2\times 10^{3}$$

$$= 8.56\,V.$$

$$r_e = \frac{26\,mV}{I_E}$$

$$= \frac{26}{0.977\,mA} = 25.6\,\Omega$$

$$A_d = \frac{R_C}{r_e + R_E'} = \frac{2.2\times 10^{+3}}{25.6 + 100\,\Omega} \simeq 17.52$$

$$R_i = 2\beta(r_e + R_E') = 2\times 100 \times (25.6 + 100)$$

$$= 25.12\,k\Omega$$

Duration .... Hours. Total Marks assigned to the paper ....

Q. No. Marks

N.B. :

Q-6-b Design $V_o = -\int V_{in} \cdot dt$

For an integrator $V_o = \frac{-1}{R_F C_F} \int_0^t V_{in} \cdot dt + C$

$\therefore \frac{1}{R_F C_F} = 1$

Let $R_F = 10k$

$\therefore C_F = \frac{1}{10 \times 10^3} = 0.1\ mF$

$f_a = \frac{1}{2\pi R_f \cdot C_F} = \frac{1}{2\pi \times 10k \times 0.1\ mF} = 0.159\ Hz$

$f_b = \frac{1}{2\pi R_1 C_F}$

Let $f_b = 10 f_a$

$\therefore f_b = 1.59$

$\therefore 1.59 = \frac{1}{2\pi R_1 \times 0.1\ mF}$

$\therefore R_1 = \frac{1}{1.59 \times 2 \times \pi \times 0.1\ mF}$

$= 1\ K\Omega$

(15)

Marks

Q. No.

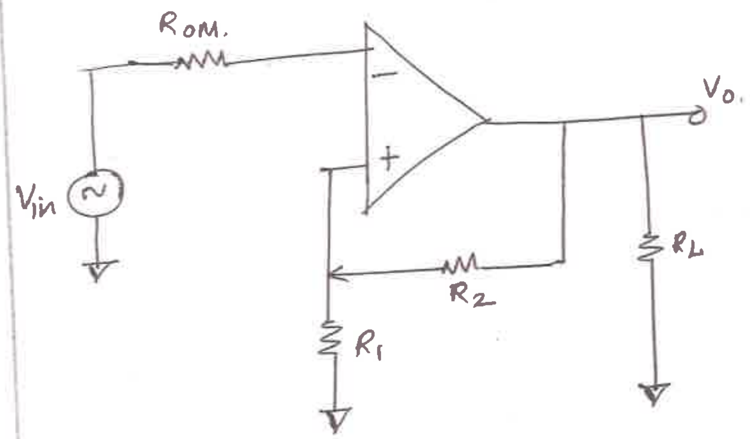
Q-6-C.

Schmitt trigger. – (NINV or INV. anyone).

ckt dia. – 1. marks.

threshold points – with explanation – 2 marks.

waveforms – 2



$$V_{ut} = \frac{R_1}{R_1 + R_2}(+V_{sat}).$$

$$V_{lt} = \frac{R_1}{R_1 + R_2}(-V_{sat})$$

$$V_{hystresis} = \frac{R_1}{R_1 + R_2}\left[V_{sat} - (-V_{sat})\right]$$