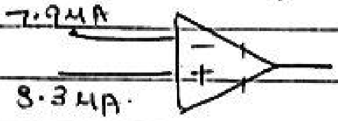
PNB

Date

Numericals :

1. Determine the input bias current and input offset current I_B & I_{io} to an OPAmp if the current into noninverting terminal is 8.3 μA & inverting terminal is 7.9 μA.



$$I_B = \frac{I_{B1} + I_{B2}}{2} = \underline{8.1 \mu A}$$

$$I_{io} = |I_{B1} - I_{B2}| = |8.3\mu A - 7.9 \mu A|$$
$$= \underline{0.4 \mu A}$$

2. A certain OP Amp has a differential voltage gain of 1,00,000 and common mode gain of $A_c = 0.25$. Determine CMRR & express it in dB.

given $A_d = 1,00,000$.
$A_c = 0.25$

$$CMRR = \frac{A_d}{A_c} = \frac{1,00,000}{0.25} = 4,00,000$$

in dB, $CMRR|_{dB} = 20 \log_{10} (4,00,000)$
$= \underline{112.04 \, dB}$

3. An OP Amp has a differential voltage gain of 2,500 and a CMRR of 30,000.
i) Determine common mode gain A_c
ii) Express CMRR in dB

PNB

Date

given $A_d = 2500$ $CMRR = 30,000$

i) $CMRR = \frac{A_d}{A_c}$

$$\therefore A_c = \frac{A_d}{CMRR} = \frac{2500}{30,000} = \underline{0.083}$$

ii) CMRR in dB $= 20 \log_{10} (30,000)$
$= \underline{89.54 \, dB}$

4. An OPAmp has a common mode input signal of 3.2V to both the input terminals. This results in an o/p signal of 26mV. Determine common mode gain A_c & CMRR in dB. given that the differential gain is 100.

given $V_c = 3.2V$, $V_o = 26\,mV$

$$A_c = \frac{V_o}{V_c} = \frac{26\,mV}{3.2\,V} = \underline{\underline{0.0081}}$$

$$CMRR = \frac{A_d}{A_c} = \frac{100}{0.0081} = \underline{12345.6}$$

$$\therefore CMRR\Big|_{dB} = 20\log_{10}(12345.6)$$

$$= \underline{\underline{81.83\,dB}}$$

Date PNB

4. In a colpitts oscillator, $C_1 = 100pF$, $C_2 = 260pF$. Find the value of L if the frequency of oscillations is 40kHz.

Solu. Given: $C_1 = 100pF$ $C_2 = 260pF$.

$L = ?$ $f = 40kHz$.

$$f = \frac{1}{2\pi\sqrt{L\,C_{eq}}} \qquad C_{eq} = \frac{C_1 C_2}{C_1 + C_2}.$$

$$C_{eq} = \frac{100\times10^{-12} \times 260\times10^{-12}}{100\times10^{-12} + 260\times10^{-12}} = \underline{\underline{37.5\,pF}}.$$

To find L. Square both sides of f.

$$f^2 = \frac{1}{4\pi^2 L\,C_{eq}}.$$

$$\therefore L = \frac{1}{4\pi^2 f^2 C_{eq}}.$$

$$= \frac{1}{4\pi^2(40\times10^3)^2(37.5\times10^{-12})}$$

$$\therefore \underline{\underline{L = 0.422H}}$$

5. In a colpitts oscillator, $L = 5mH$. Find C_1 and C_2 if the frequency of oscillations is $f = 50 kHz$. Assume a feedback factor of $\beta = 10\%$

Soln. $L = 5mH$. $f = 50kHz$. $\beta = 10\% = 0.1$

$$f = \frac{1}{2\pi\sqrt{L C_{eq}}} \qquad C_{eq} = \frac{C_1 C_2}{C_1 + C_2}$$

Squaring f,

$$f^2 = \frac{1}{4\pi^2 L C_{eq}}$$

$$C_{eq} = \frac{1}{4\pi^2 L f^2} = \frac{1}{4\pi^2 \times 5\times10^{-3} \times (50\times10^3)^2}$$

$$C_{eq} = 2.02nF$$

wkt $C_{eq} = \frac{C_1 C_2}{C_1 + C_2}$, $\beta = 0.1 = \frac{C_2}{C_1}$

$$\therefore \underline{C_2 = 0.1 C_1}$$

$$C_{eq} = \frac{C_1 C_2}{C_1 + C_2} = \frac{C_1 \times 0.1 \cancel{C_1}}{1.1 \cancel{C_1}} = \frac{0.1 C_1}{1.1}$$

$$\Rightarrow C_{eq} = \frac{0.1 C_1}{1.1}$$

$$2.02nF = \frac{0.1 C_1}{1.1}$$

$$\therefore \underline{\underline{C_1 = 22.22nF}}$$

$$\& \quad C_2 = 0.1 \times 22.22nF$$

$$= \underline{\underline{2.222nF}}$$

Date PNB

5. Design a Colpitts oscillator whose frequency of oscillation is 40 kHz, $L = 10 mH$ and $C_1 = C_2 = C$.

Soln. $C_1 = C_2 = C$, $f = 40 kHz$, $L = 10 mH$.

$$C_{eq} = \frac{C_1 C_2}{C_1 + C_2} = \frac{C^2}{2C} = \frac{C}{2}.$$

$$\therefore f = \frac{1}{2\pi\sqrt{C_{eq} L}}$$ squaring f,

$$f^2 = \frac{1}{4\pi^2 C_{eq} L}.$$

$$C_{eq} = \frac{1}{4\pi^2 L f^2}.$$

$$\frac{C}{2} = \frac{1}{4\pi^2 (40\times10^3)^2 \times 10\times10^{-3}}$$

$$\therefore C = 3.166 nF.$$

$$C_1 = C_2 = \underline{\underline{3.166 nF}}$$

1. An inverting amplifier has $R_1 = 1k\Omega$ and $R_f = 20k\Omega$. calculate the gain A.

Soln. given $R_1 = 1k\Omega$ $R_f = 20k\Omega$

$$\therefore A = -\frac{R_f}{R_1} = -\frac{20k\Omega}{1k\Omega} = -20.$$

2. An OP-Amp in inverting configuration has a gain of +40. If the applied i/p voltage is 3mV what is V_o?

Soln. given $A = +40$.

$V_i = 3mV$.

$$\therefore V_o = -\frac{R_f}{R_1} V_i = -A V_i$$

$$\therefore V_o = -40\,(3\,mV)$$

$$V_o = -120\,mV.$$

3. Design an inverting amplifier with a gain of -50 and a $2k\Omega$ resistance R_1. Draw the circuit fig.

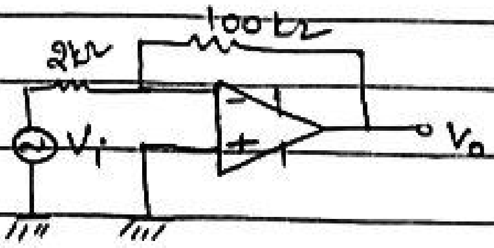
Soln. given $R_1 = 2k\Omega$. $A = -50$.

To calculate feedback resistor R_f.

WKT $A = -\frac{R_f}{R_1}$ for inverting amplifier.

$$\therefore -50 = -\frac{R_f}{2k\Omega}$$

$$\Rightarrow R_f = 100\,k\Omega$$



4. A sine wave of 0.5V peak value is applied as an i/p to an inverting amplifier with $R_1 = 10k\Omega$ and $R_f = 50k\Omega$. It uses a power supply of $\pm 12V$. Determine the output voltage and sketch i/p & o/p waveforms. If now an i/p voltage of 5V peak is applied, what is the o/p. Sketch the waveforms.

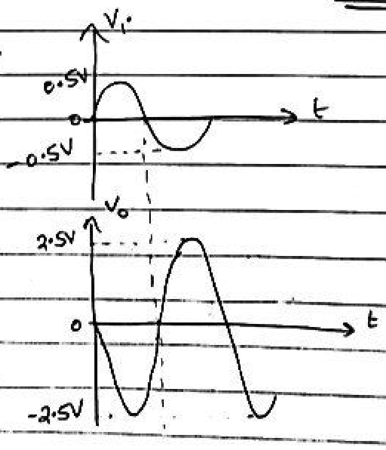
Soln: given $V_i = 0.5V_p$ $R_1 = 10k\Omega$ $R_f = 50k\Omega$

(i) It gives an o/p voltage for a supply of $\pm 12V$. So $V_o = ?$

wkt $V_o = -\frac{R_f}{R_1} V_i = -\frac{50k\Omega}{10k\Omega} V_i = -5(0.5V)$

$\therefore V_o = -2.5V_p$ or $-5V_{p-p}$

waveforms



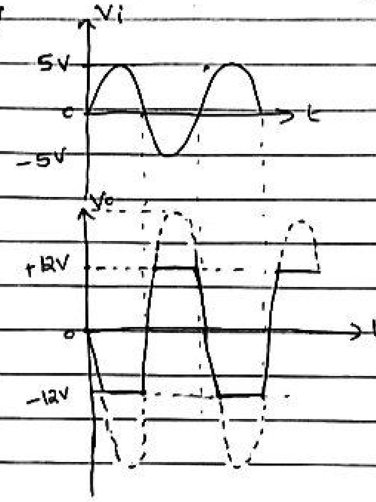
(ii) If a $5V_p$ is applied as i/p voltage $V_o = ?$

$V_o = -\frac{R_f}{R_1} V_i = -5 \times 5V_p$

$= -25V_p$ or $-50V_{p-p}$

But given $+V_{cc}$ & $-V_{EE}$ supplies as $\pm 12V$.
Hence the o/p voltage will saturate at $\pm 12V$.
(The peak levels get clipped off after $\pm 12V$).

waveforms



5. In a non-inverting amplifier using OP-Amp, $R_1 = 2k\Omega$, $R_f = 200k\Omega$. Supply voltages are $\pm 15V$. calculate V_o if the applied i/p voltage is $1.5V_{pp}$

Solu: given : $R_1 = 2k\Omega$. $R_f = 200k\Omega$.

$\pm V_{CC}, -V_{EE} = \pm 15V$.

$$V_o = \left(1 + \frac{R_f}{R_1}\right) V_i$$

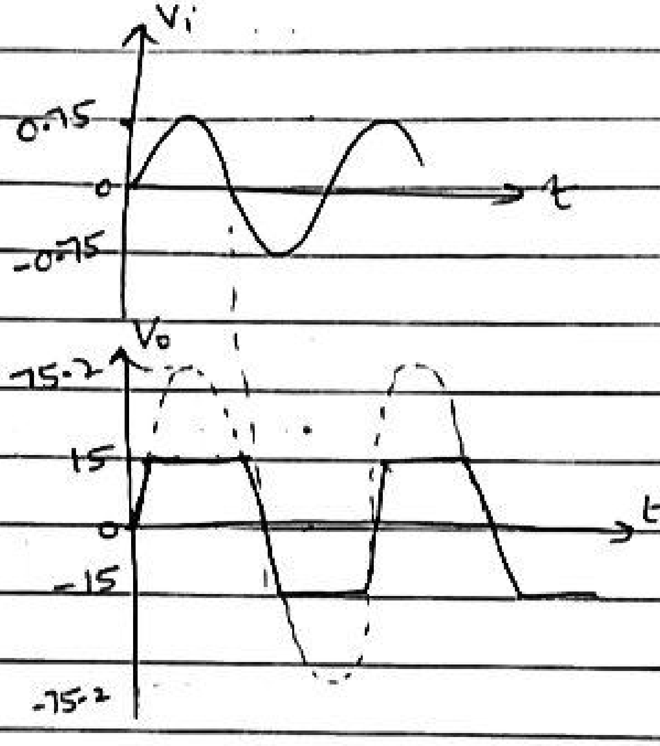
Date

$$V_o = \left(1 + \frac{200k\Omega}{2k\Omega}\right) 1.5V_{pp}$$

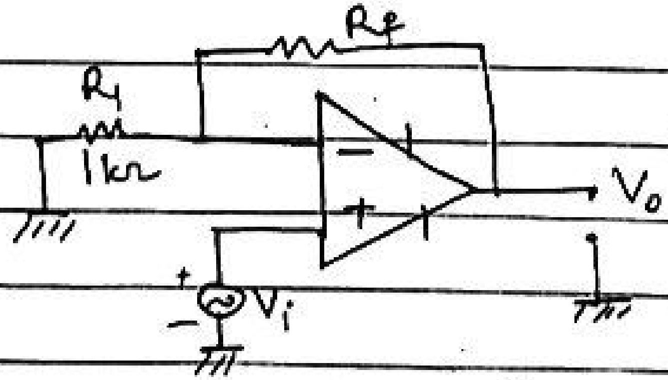
$$= \underline{\underline{151.5 V_{p-p}}}$$

given $V_i = 1.5V_{pp}$ with $\pm 15V$ supply voltages. O/P will saturate at $\pm 15V$.

Waveforms



6. For an Op-Amp circuit shown in figure below gain is 60. $R_1 = 1k\Omega$ what is R_f?



It is a non inverting amplifier circuit.

Hence $$V_0 = \left(1 + \frac{R_f}{R_1}\right) V_i$$

PNB

Date

where closed loop gain

$$A = 1 + \frac{R_f}{R_1} \quad \text{given } A = 6.$$

$$60 = 1 + \frac{R_f}{1k\Omega}$$

$$\text{or } \frac{R_f}{1k\Omega} = 59.$$

$$\text{or } R_f = 59 \times 1k\Omega$$

$$R_f = \underline{\underline{59 k\Omega}}$$

Hence $V_o = \left(1+\frac{R_f}{R_1}\right)V_i$

10:32 AM

PNB

Date

where closed loop gain

$$A = 1 + \frac{R_f}{R_1} \quad \text{given } A = 60.$$

$$60 = 1 + \frac{R_f}{1k\Omega}$$

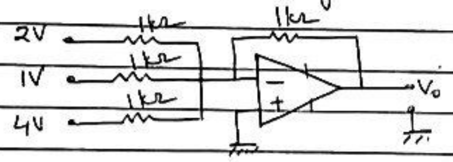
$$\text{or } \frac{R_f}{1k\Omega} = 59.$$

$$\text{or } R_f = 59 \times 1k\Omega$$

$$R_f = 59k\Omega$$

Inverting Summer.

7. In the circuit figure of an inverting summer determine the o/p voltage.



Soln: o/p voltage of an inverting summer is

$$V_o = -\left(\frac{R_f}{R_1}V_1 + \frac{R_f}{R_2}V_2 + \frac{R_f}{R_3}V_3\right)$$

Since $R_f = R_1 = R_2 = R_3 = 1k\Omega$,

$$V_o = -(2V + 1V + 4V)$$

$$= -7V$$

For the same circuit if $R_1 = 2k\Omega$, $R_2 = 1k\Omega$ & $R_3 = 4k\Omega$, $R_f = 20k\Omega$, $V_o = ?$

Date PNB

$$V_o = -\left(2\frac{20k\Omega}{2k\Omega} + 1\frac{20k\Omega}{1k\Omega} + 4\frac{20k\Omega}{4k\Omega}\right)$$

$$= -(20 + 20 + 20)$$

$$= -60V$$

8. Design an inverting summer using Op-Amp to give an o/p voltage $V_o = -(3V_1 + 4V_2 + 5V_3)$, with $R_f = 120k\Omega$.

Soln: For an inverting summer,

$$V_o = -\left(\frac{R_f}{R_1}V_1 + \frac{R_f}{R_2}V_2 + \frac{R_f}{R_3}V_3\right) \quad -(1)$$

$R_f = 120k\Omega$.

given $V_o = -(3V_1 + 4V_2 + 5V_3)$ $-(2)$

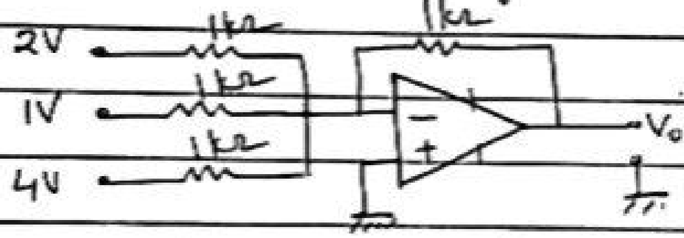
equating (1) & (2),

$$\frac{R_f}{R_1} = 3 \Rightarrow \frac{120k}{3} = R_1 = 40k\Omega$$

$$\frac{R_f}{R_2} = 4 \Rightarrow \frac{120k}{4} = R_2 = 30k\Omega$$

Inverting Summer.

7. In the circuit figure of an inverting summer determine the o/p voltage.



Soln. o/p voltage of an inverting summer is

$$V_o = -\left(\frac{R_f}{R_1}V_1 + \frac{R_f}{R_2}V_2 + \frac{R_f}{R_3}V_3\right)$$

Since $R_f = R_1 = R_2 = R_3 = 1k\Omega$,

$$V_o = -(2V + 1V + 4V)$$
$$= \underline{\underline{-7V}}$$

For the same circuit if $R_1 = 2k\Omega$, $R_2 = 1k\Omega$ & $R_3 = 4k\Omega$, $R_f = 20k\Omega$, $V_o = ?$

Date PNB

$$V_o = -\left(2\,\frac{\overset{10}{20k\Omega}}{2k\Omega} + 1\,\frac{20k\Omega}{1k\Omega} + 4\,\frac{20k\Omega}{4k\Omega}\right)$$
$$= -(20 + 20 + 20)$$
$$= \underline{-60V}$$

8. Design an inverting summer using OP.Amp to give an o/p voltage $V_0 = -(3V_1 + 4V_2 + 5V_3)$, with $R_f = 120k\Omega$.

Solu: For an inverting summer,

$$V_0 = -\left(\frac{R_f}{R_1}V_1 + \frac{R_f}{R_2}V_2 + \frac{R_f}{R_3}V_3\right) \quad -(1)$$

$R_f = 120k\Omega$.

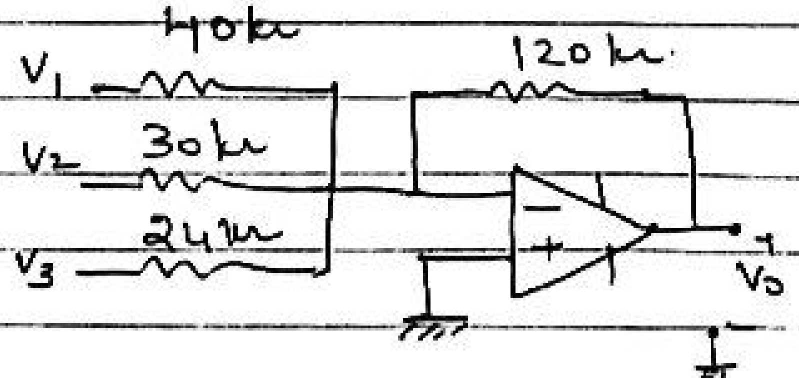
given $V_0 = -(3V_1 + 4V_2 + 5V_3) \quad -(2)$

equating (1) & (2),

$$\frac{R_f}{R_1} = 3 \Rightarrow \frac{120k}{3} = R_1 = \underline{40k\Omega}$$

$$\frac{R_f}{R_2} = 4 \Rightarrow \frac{120k}{4} = R_2 = \underline{30k\Omega}$$

$$\frac{R_f}{R_3} = 5 \Rightarrow \frac{120k}{5} = R_3 = \underline{24k\Omega}$$



9. Design an inverting summer for

$V_0 = 0.2V_1 + 1V_2 + 4V_3$ with $R_f = 20k\Omega$

Date PNB

Soln : Output voltage for an inverting summer is

$$V_0 = -\left(\frac{R_f}{R_1}V_1 + \frac{R_f}{R_2}V_2 + \frac{R_f}{R_3}\right) \quad -(1)$$

Given $V_0 = 0.2V_1 + 1V_2 + 4V_3$.

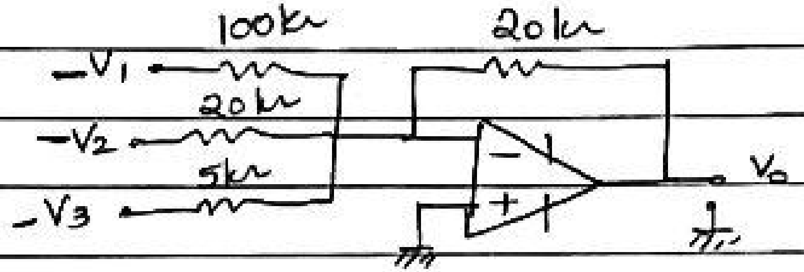
ie $V_0 = -(0.2(-V_1) + 1(-V_2) + 4(-V_3)) \quad -(2)$

comparing (1) & (2)

$$\frac{R_f}{R_1} = 0.2 \Rightarrow \frac{20k\Omega}{0.2} = R_1 = \underline{100k\Omega}$$

$$\frac{R_f}{R_2} = 1 \Rightarrow \frac{20k\Omega}{1} \Rightarrow R_2 = \underline{\underline{20k\Omega}}$$

$$\frac{R_f}{R_3} = 4 \Rightarrow \frac{20k\Omega}{4} = R_3 = \underline{\underline{5k\Omega}}$$



Numericals on IC 555 timer.

10. For an IC 555 timer to work in astable mode the components considered are $R_1 = 1k\Omega$ $R_2 = 10k\Omega$ with $C_1 = 0.01\mu F$. What is the frequency of oscillations generated? Duty cycle?

Sol. given $R_1 = 1k\Omega$, $R_2 = 10k\Omega$ $C_1 = 0.01\mu F$.

$$f = \frac{1}{T}, \quad T = T_{ON} + T_{OFF}.$$

$$T_{ON} = 0.693\,(R_1 + R_2)C$$
$$= 0.693\,(1k\Omega + 10k\Omega)\,0.01\mu F$$
$$= 0.693\,(11k\Omega)\,0.01\mu F$$

What makes you happy?

#

Date P NB

$$= 0.693\,(11 \times 10^{+3} \times 0.01 \times 10^{-6})$$
$$= 0.693\,(11 \times 0.01 \times 10^{-3})$$

$T_{ON} = 76.23\,\mu sec$

$$T_{OFF} = 0.693\,R_2 C = 0.693 \times 10k\Omega \times 0.01\mu F$$
$$= 0.693 \times 10 \times 10^{3} \times 0.01 \times 10^{-6}$$
$$= 0.0693 \times 10^{-3}$$
$$= 69.3 \times 10^{-6}\,sec$$

$\therefore T = 145.53\,\mu sec$

$f = 6.871\,KHz$ $\quad \left(f = \frac{1}{T}\right)$

$$\text{Duty cycle} = \frac{T_{ON}}{T} = \frac{76.23\,\mu sec}{145.53\,\mu sec}$$
$$= 0.5238.$$

$\% D = 52.38\%$

11. A 555 timer IC has $R_1 = 4k\Omega$, $R_2 = 4k\Omega$, $C = 0.01\mu F$, $f = ?$ $D = ?$

Ans: $f = 12kHz$ $D = 66.67\%$

12. For an IC timer based astable multivibrator given $D = 75\%$, $f = 1kHz$ $R_2 = 3.6k\Omega$ $C = 0.1\mu F$, calculate T_{ON} and R_1.

Solu: given $D = 0.75$, $f = 1kHz$ $R_2 = 3.6k\Omega$, $C = 0.1\mu F$.

$$\therefore T = \frac{1}{f} = 1 msec$$

Scanned by CamScanner

Date: PN 8

$$\text{Duty cycle} = \frac{T_{ON}}{T}$$

$$\therefore T_{ON} = D \times T$$
$$= 0.75 \times 1 \times 10^{-3}$$
$$= 750 \mu sec$$

$$T_{ON} = 0.693(R_1 + R_2)C.$$
$$750 \times 10^{-6} = 0.693(R_1 + 3.6k\Omega)0.1 \times 10^{-6}$$
$$= 6.93 \times 10^{-8} R_1 + 2.4948 \times 10^{-4}.$$

$$\therefore 750 \times 10^{-6} - 249.48 \times 10^{-6} = 6.93 \times 10^{-8} R_1.$$
$$501 \times 10^{-6} = 6.93 \times 10^{-8} R_1$$
$$\therefore R_1 = 72.29 \times 100$$
$$= 7.229 k\Omega$$

13. For an IC 555 timer, $D = 60\%$, $f = 2kHz$ $R_2 = 3k\Omega$, $C = 0.1\mu F$. $R_1 = ?$
Solve the problem.

PROBLEMS ON IC 555 TIMER:

1) For an IC 555 timer, T_{ON} = 3sec, T_{OFF} = 1sec and C = 10µF. Calculate the Value of R_1 and R_2.

Solution:

Given: $T_{ON} = 3sec$, $T_{OFF} = 1sec$, $C = 10\mu F$

Solution:

$$T_{OFF} = 0.693\, R_2\, C$$

$$1 = 0.693 \times R_2 \times 10 \times 10^{-6}$$

R_2 = 144 KΩ

$$T_{ON} = 0.693(R_1 + R_2)C$$

Therefore R_1 = 288.6 KΩ

2) For an IC 555 timer, given D = 75%, f= 1 KHz, R_2 = 3.6 kΩ, C = 0.1µF. Calculate R_1.

Solution:

Given: $D = 75\% \Rightarrow 0.75$

$f = 1\ kHz$, $R_2 = 3.6\ k\Omega$, $C = 0.1\mu F$

$$D = \frac{T_{ON}}{T}$$

$$T = \frac{1}{f} \Rightarrow 1\text{ m sec}$$

$$T_{ON} = D \times T$$

$$T_{ON} = 0.75 \times 10^{-3} sec = 750\ \mu sec$$

$$T_{OFF} = 0.693\ R_2\ C$$

$$T_{OFF} = 249\ \mu sec$$

Since $D > 50\%$. $T_{ON} > T_{OFF}$

$$T_{ON} = 0.693(R_1 + 3600)0.1 \times 10^{-6}$$

Therefore R_1 = 7.215 kΩ

Problems on RC oscillator:

1. In an RC phase shift oscillator, R = 500Ω and C=0.1μF. Calculate the frequency of oscillations.

Solution:

Given R = 500Ω, C=0.1μF

Frequency of oscillations is given by

$$f = \frac{1}{2\pi RC\sqrt{6}}$$

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

$$\therefore \ f = 1.299kHz$$

2. In an RC phase shift oscillator, R = 1000Ω. If the frequency of oscillations is 5kHz, calculate the value of C.

Solution:

Given R = 1000Ω, f = 5kHz.

Frequency of oscillations is given by

$$f = \frac{1}{2\pi RC\sqrt{6}} \text{ or } C = \frac{1}{2\pi Rf\sqrt{6}}$$

$$\therefore C = \frac{1}{2\pi \times 1000 \times 5000\sqrt{6}}$$

$$C = 0.0129\mu F$$