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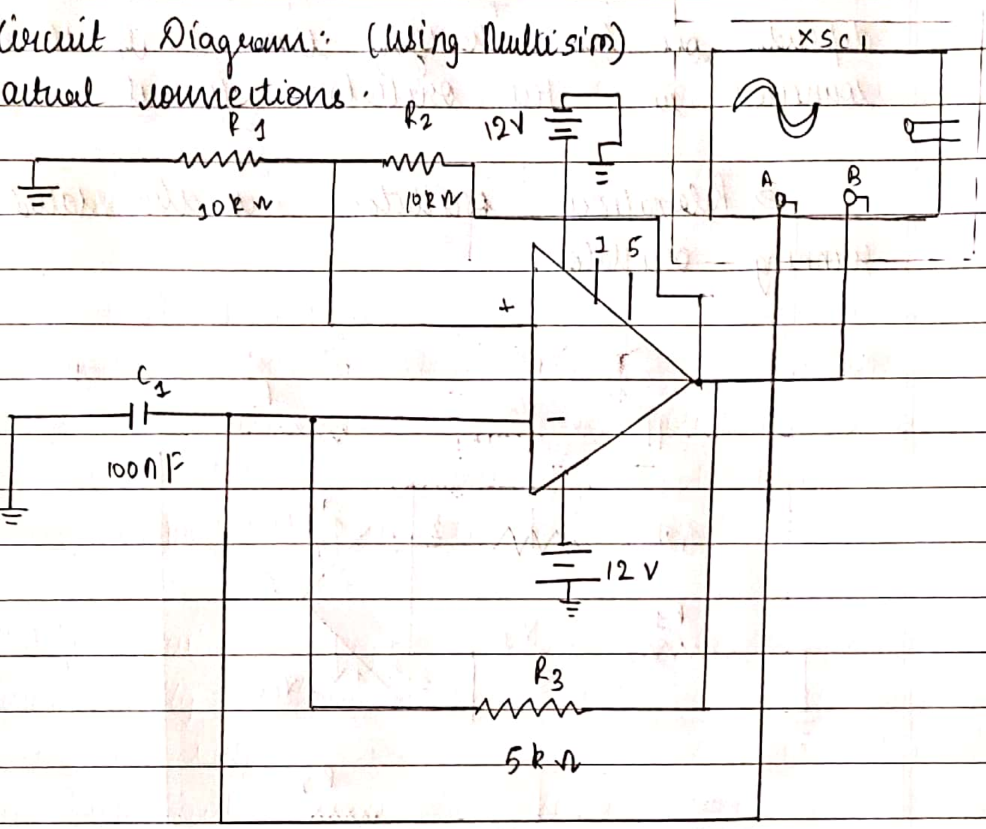
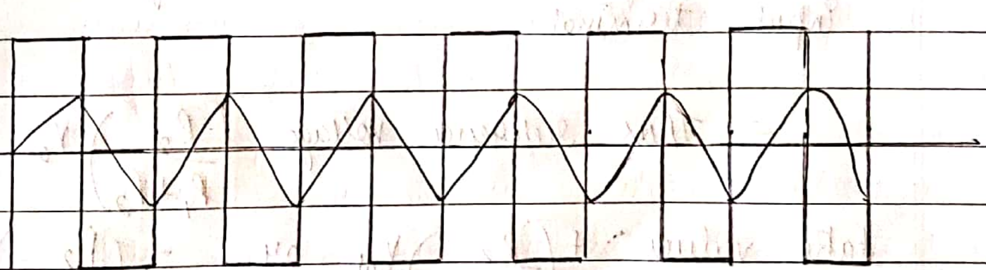
To design and implement a rectangular waveform generator (op-amp relaxation oscillator) for a given frequency.

Circuit Diagram: (Using Multisim)
And actual connections.

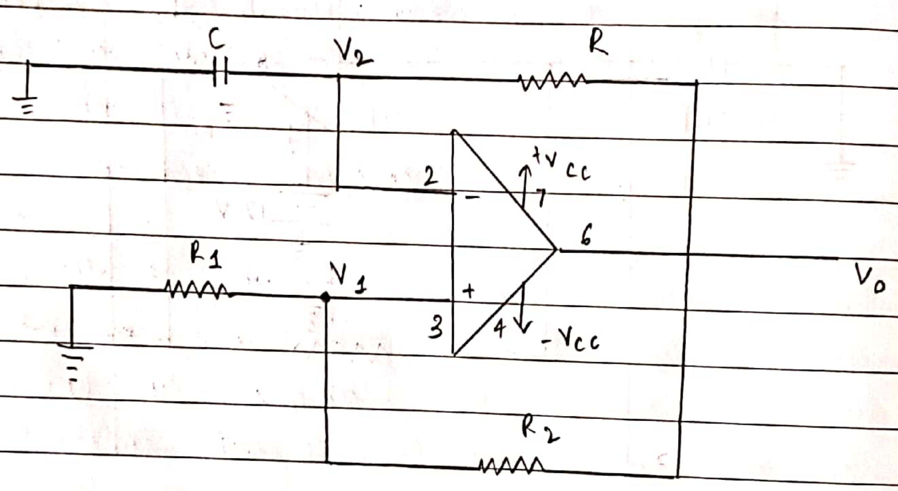


Waveform:



Relaxation oscillator: Is a non-linear electronic oscillator circuit that generates a continuous non-sinusoidal output signal in the form of rectangular wave, triangular wave or a saw-t wave. The time period of non-sinusoidal output depends on the charging time of the capacitor connected in the oscillator circuit.

→ Relaxation oscillator is also called as free running oscillator.



→ In this figure the op-amp operates in the saturation region. Here, a fraction $\left(\frac{R_2}{R_1+R_2}\right)$ of output is fed back to non inverting input terminal.

→ Thus reference voltage $\left(\frac{R_2}{R_1+R_2}\right)V_o$ and may take values $+\left(\frac{R_2}{R_1+R_2}\right)V_{sat}$ or $-\left(\frac{R_2}{R_1+R_2}\right)V_{sat}$

→ The output is also fed back to the inverting input terminal after integrating by means of low-pass RC combination. Thus whenever

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the voltage at inverting input terminal just exceeds reference voltage, switching takes place resulting in a square wave output.

Design:

Time period of the output waveform is given by $T = 2RC \ln\left(\frac{1+\beta}{1-\beta}\right) \rightarrow ①$

where $\beta = \frac{R_1}{R_1 + R_2}$

If $R_2 = 1.16 R_1$, then $\beta = 0.463$

From ①, $T = 2RC \ln\left(\frac{1.463}{0.537}\right) = 2RC \ln(e)$

$T = 2RC$

$R = \frac{T}{2C} \rightarrow ②$

For given frequency of 1 KHz.

$T = \frac{1}{f} = \frac{1}{1000} = 1 \times 10^{-3} s$

If we take $R_1 = 10\,k\Omega$ and $R_2 = 11.6\,k\Omega$

If we take $C = 0.1\,\mu F$

then from ②

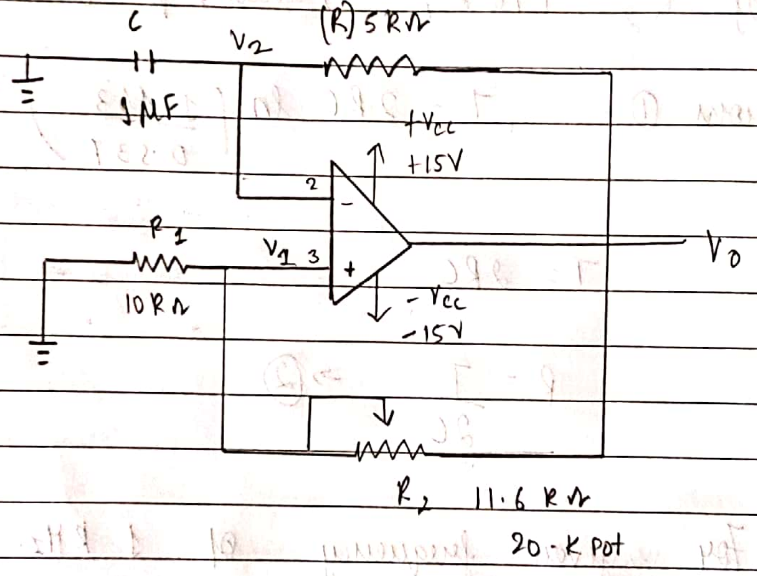
$R = \frac{T}{2C} = \frac{10^{-3}}{2 \times 0.1 \times 10^{-6}} = 5\,k\Omega$

The voltage across the capacitor has a peak voltage of $V_c = \frac{R_1}{R_1 + R_2} V_{sat}$

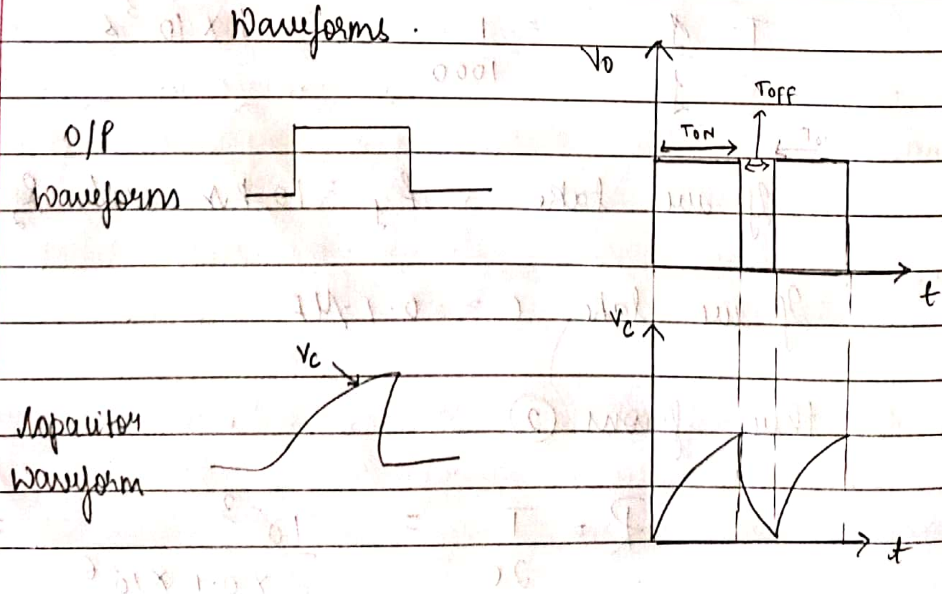
$$V_{sat} = 90\% \ V_{cc}$$
$$= \frac{90}{100} \times 15 = 13.5 \simeq 12V$$

$$V_c = \frac{10}{10 + 11.6} \times 12 = 5V.$$

Relaxation oscillator : circuit diagram and actual connections



Waveforms.



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Relaxation Osillator

Result :

Sl No	f KHz	R	
1	1 KHz	5 kΩ	5 V
2	1.5 KHz	3.335 kΩ	5 V
3	2 KHz	2.5 kΩ	5 V

$$R = \frac{T}{2C} = \frac{0.667 \times 10^{-3}}{2 \times 0.1 \times 10^{-6}} \qquad T = \frac{1}{1.5 \times 10^{+3}}$$

$$= 3.335 \text{ k}\Omega$$

$$R = \frac{T}{2C} = \frac{0.5 \times 10^{-3}}{2 \times 0.1 \times 10^{-6}} \qquad T = \frac{1}{2 \times 10^{3}}$$

$$= 2.5 \times 10^{3} \ \Omega$$