# Operational Amplifier as astable multivibrator

**Aim** :- To construct an astable multivibrator using operational amplifier 741 for getting square wave and to determine the frequency of oscillation and comparing it with that of theoretical value.

**Apparatus** :- Operational amplifier ( IC 741 ), C.R.O., two power supplies to the operational amplifier, two non inductive fixed resistors ($R_1$ and $R_2$ ), one non-inductive variable resistor(R), capacitor and connecting terminals.

**Formula** :- Time period of the square wave

$$T = 2 \times 2.303\ RC\ \log_{10}\left(\frac{2R_1+R_2}{R_2}\right)\ \text{Sec}$$

Where R, $R_1$ and $R_2$ = Resistances (Ω)

C = Capacitance (μF)

∴ Frequency of the square wave $f = \frac{1}{T}$ Hz

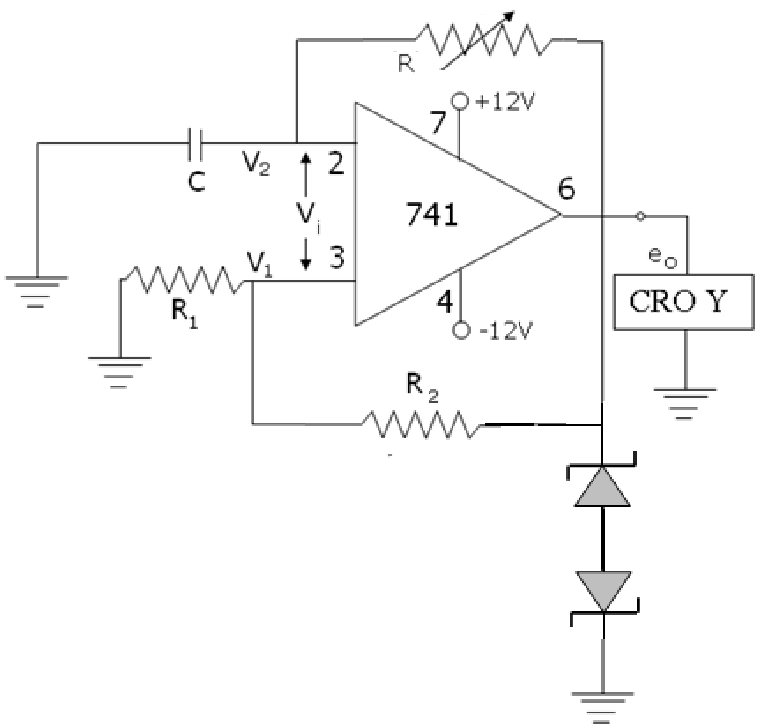


**Fig - 1**

**Description** :- An astable multi vibrator or free running multi vibrator generates square waves of its own i.e. without any external excitation. It has no stable state but has only two quasi stable (half stable) states between which it keeps on oscillating on its own accord.

Fig-1 is the circuit of the astable multi vibrator. A capacitor C is connected to the inverting terminal (2) of the operational amplifier from the ground. Similarly a resistance $R_1$ is connected to the non-inverting terminal (3) of the operational amplifier from the ground. The output terminal (6) of the amplifier is fed back to inverting and non-inverting terminals of operational amplifier through resistors R and $R_2$ respectively. Here $R_2$ is fixed resistor and R is variable resistor. To observe the out put wave form, the out put terminal (6) is connected to CRO Y- Plates phase terminal and the other terminal of CRO is grounded. The terminals (7) and (4) of the op. amp. are connected to +12 V and -12 V of the D.C. power supplies separately. The out put terminal (6) is also grounded through a series combination of two zener diodes connected in reverse order as shown in the fig-1.

**Theory** :- First the inverting terminal (2) is at zero potential ($V_2 = 0$, the inverting terminal 2 is virtually grounded) and the input at the non-inverting terminal (3) has some potential $V_1$ i.e the voltage across $R_1$. This occurs due to the power supply of the operational amplifier. The potential difference between the two input terminals (inverting and non-inverting terminals) is

$$V_i = V_1 - V_2$$
$$= V_1 - 0$$
$$= V_1 \qquad \text{Here } V_1 \text{ is +ve.} \quad (\because V_2 = 0)$$

This '+ ve' voltage drives the output of operational amplifier into '+ ve' saturation voltage ($+V_{sat}$). This large saturation voltage is due to the high gain of the operational amplifier i.e. the comparator character of the amplifier. When the $+ V_{sat}$ is fed back to the inverting terminal (2) through the resistor R, the capacitor C gets charged and the potential of the right side plate of the capacitor gradually rises (or) the $V_2$ value rises (Even though the inverting terminal 2 is virtually grounded but it is not mechanically grounded). When $V_2$ becomes slightly more than $V_1$, the in put ( $V_i = V_1 – V_2$ ) becomes '–ve' and immediately this '–ve' voltage drives the out put of the operational amplifier in to '–ve' saturation voltage ($- V_{sat}$).

Now the capacitor discharges gradually. When $V_2$ becomes less than $V_1$ and $(V_1 - V_2)$ becomes '+ve' and the out put drives to $+V_{sat}$. The same process is repeated and the out put of the operational amplifier swings between two saturation voltages i.e. between $+V_{sat}$ and $-V_{sat}$. The out put $e_o$ of the operational amplifier is square wave. So, operational amplifier can function as a square wave generator. The wave shape is as shown in Fig-2.

The duration of saturation is

$$t = \frac{T}{2} = \text{RC} \log_e \left(\frac{1+\beta}{1-\beta}\right) \text{ Sec}$$

Where $\beta = \left(\frac{\mathbf{R_1}}{\mathbf{R_1+R_2}}\right)$ = Feed back factor

Then $t = \frac{T}{2} = \text{RC} \log_e \left(\frac{2R_1+R_2}{R_2}\right)$ Sec

(OR)

$$T = 2 \text{ x } 2.303 \text{ RC} \log_{10} \left(\frac{2R_1 + R_2}{R_2}\right) \text{ Sec}$$

( Note : If $R_1 = R_2$ then T = 2.1976 RC )

From this the frequency of oscillation $f = \frac{1}{T}$ Hz can be calculated.

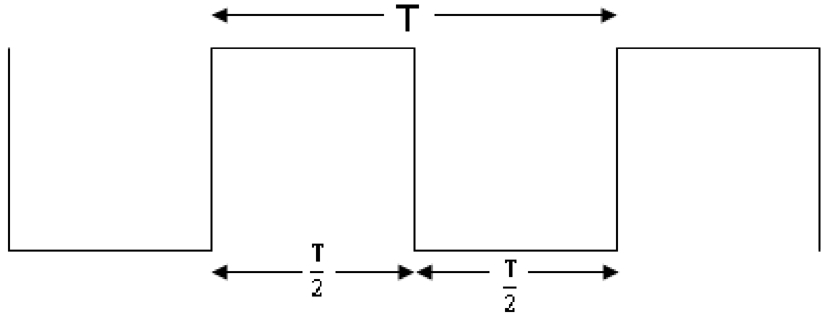


**Fig -2**

**Procedure** :- Connect the circuit as shown in the Fig-1. Take the $R_1 = R_2 = 1K\Omega$, $C = 0.1\mu F$and $R = 10K\Omega$ (variable resistance) or any convenient values. Apply the DC power supplies to the terminals (7) and (4) of the operational amplifier. Keep the $R_2$ value at a convenient value. Set the voltage sensitivity band switch of the Y- plate and time base band switch of C.R.O. to the convenient positions such that at least two or more complete square wave forms are observed on the screen of CRO. Now measure the horizontal length (l) of one complete wave form as shown in the Fig-2. Also note the time base value (m) in the table. From this calculate the time period and frequency of the square wave as per the table. This is the experimental frequency. Similarly the theoretical frequency can also be calculated by substituting the values of R, $R_1$, $R_2$ and C in the above given equation.

Now the experiment is repeated for different values of R by increasing its value in equal steps ( Multiples of 100 Ω ).

**Precautions** :- 1. Check the continuity of the connecting terminals before connecting them.

2. Keep the band switches of the C.R.O. such that steady wave forms are observed on the screen.

3. Observe the out put square wave on the screen of CRO and measure the horizontal length accurately.

**Results** :- It is found that the observed frequency and calculated frequency are equal.

## Table

$R_1 =$ Ω $R_2 =$ Ω C = μF

| S. No. | Resistance R (Ω) | Frequency of the Square wave (Experimental) | | | | Theoretical frequency | |
|---|---|---|---|---|---|---|---|
| | | Horizontal length (Divisions) (l) | Time base (Sec/Div) (m) | Time period T = m x l (Sec) | Frequency $f = \frac{1}{T}$ (Hz) | Time period $T = 2 \times 2.303\ RC\ \log_{10}\left(\frac{2R_1+R_2}{R_2}\right)$ (Sec) | Frequency $f = \frac{1}{T}$ (Hz) |
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