Astable Multivibrator

The operational amplifier operating as free running (astable) multivibrator is shown in figure - 1

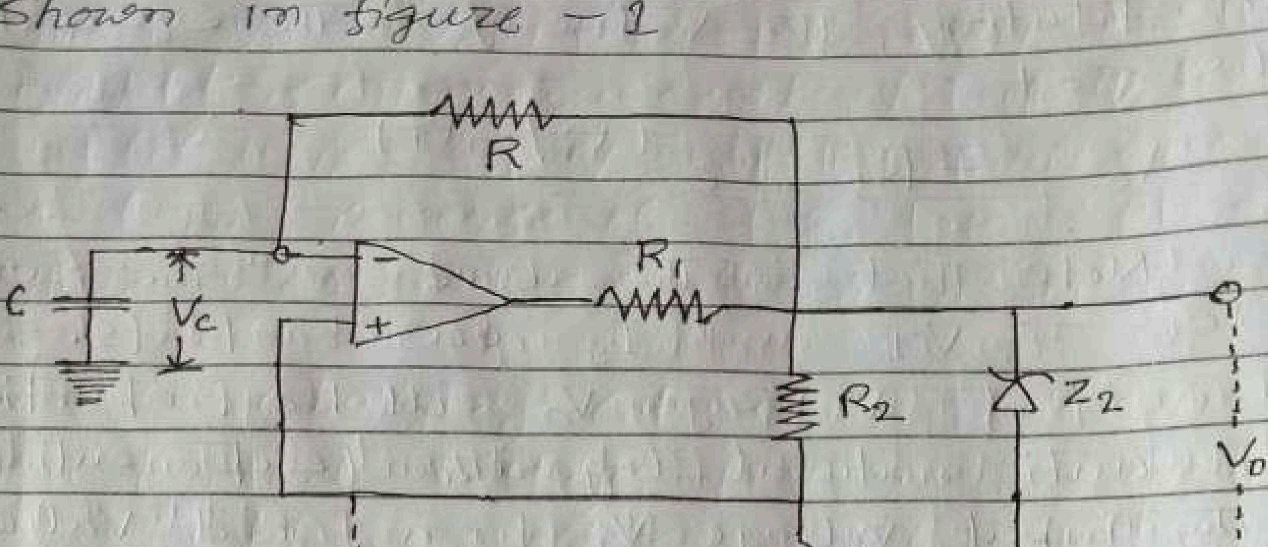

fig-1

Astable Multivibrator

In free running multivibrator, There are two states which remain momentarily stable and the circuit switches repeatedly between these two states. OP-amplifier enjoys both +ve and −ve feedbacks and ~~have~~ has a timing capacitor C, at its inverting input terminal.

The output voltage V_0 is limited by the break down voltage $+V_{0S}$ and $-V_{0S}$ of the two Zener diodes Z_1 and Z_2 connected back to back across the output terminals of the op-amplifier. Thus V_0 will be either $+V_{os}$ (or V_{os}^{+}) or $-V_{os}(V_{os}^{-})$. A fraction $\beta = R_3/(R_2+R_3)$ of V_0 is fedback to the non-inverting input. Thus in one state the amplifier output reaches a +ve saturation level ($V_0 = -V_{os}$. diode Z_1) The output waveform in Thus a square wave figure ②

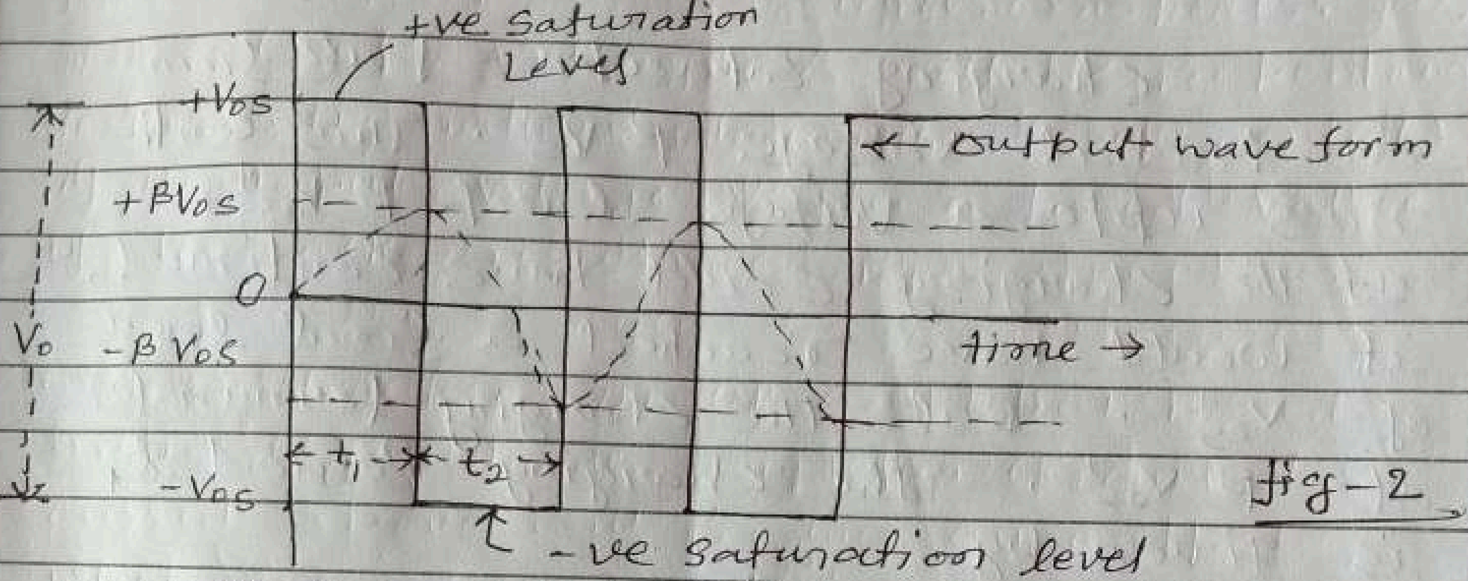

fig-2

<u>output</u> waveform of free running multivibrator

The input voltage V_{in} to the amplifier is

$$V_{in} = V_c - \beta V_0$$

When $V_{in} < 0$, or $V_c < \beta V_0 = \beta V_{os}^{+}$ Capacitor C charges exponentially towards V_{os}^{+} Through a time Constant RC. The output V_0, remains constant at V_{os}^{+} until $V_c = \beta V_{os}^{+}$ So, That $V_{in} = V_c - \beta V_{os}^{+} = 0$, i.e. The Potential difference between the two input terminals approaches Zero, and the amplifier output

reverses to V_{os}. Now c charges exponentially towards V_{os}.
Then $V_i = V_c - \beta V_0 = V_c + \beta V_{os}^+$. The output remains constant at V_{os}^- until $V_c = -\beta V_{os}^-$ at which $V_i = 0$ and the reverse of state takes place. These waveform are shown in fig-2.

Charging capacitor starts from an initial voltage βV_{os}^-. This continues upto a voltage level βV_{os}^+. If the charging could have continued, it would have reached a final level of V_{os}^+. But the charging terminates at βV_{os}^+. The charging period t_1 is given by

$$t_1 = RC \log_e \frac{V_{os}^+ - \beta V_{os}^-}{V_{os}^+ - \beta V_{os}^+}$$

$$= RC \log_e \frac{V_{os}^+ - \beta V_{os}^-}{V_{os}^+ (1-\beta)}$$

The 2nd charging time from βV_{os}^+ to $-\beta V_{os}^-$ will be

$$t_2 = RC \log_e \frac{V_{os}^- - \beta V_{os}^+}{V_{os}^- (1-\beta)}$$

If $V_{os}^+ = V$ and $V_{os}^- = -V$ then $t_1 = t_2$ so that we shall have period of one oscillation or time period as

$$T = t_1 + t_2$$

$$= RC \log_e \frac{V+\beta V}{V(1-\beta)} + RC \log_e \frac{-V-\beta V}{-V(1-\beta)}$$

$$= RC \log_e \frac{(1+\beta)}{(1-\beta)} + RC \log_e \frac{(1+\beta)}{(1-\beta)}$$

$$= 2RC \log_e \frac{(1+\beta)}{(1-\beta)} \quad \text{———} ①$$

$$= 2RC \log_e \frac{1+R_3/(R_2+R_3)}{1-R_3/(R_2+R_3)}$$

$$= 2RC \log_e \left[1 + \frac{2R_3}{R_3}\right]$$

If β is chosen to be 0.473 Then $T = 2RC$, so That frequency of oscillation is

$$f = \frac{1}{T} = \frac{1}{2RC}.$$

From equ^n ①, we observe That time period is independent of saturation level V_{os}^{+} and V_{os}^{-} and depends only on time constant RC and feedback factor B

Astable multivibrator is very useful for fixed frequency applications in audio frequency range (10 c/s – 10 Kc/s), At frequencies greater Than 10 Kc/s, The delay time of The amplifier for going from one state of saturation to another state of saturation becomes significant further, slew rate of OP-amplifier also sets a limit on the rise and fall times of square wave output waveform.