ASTABLE MULTIVIBRATOR

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Astable multivibrator has two states which remain momentarily stable and is also known as "free running multivibrator. An operational amplifier can be used as an astable multivibrator as shown in fig (1)

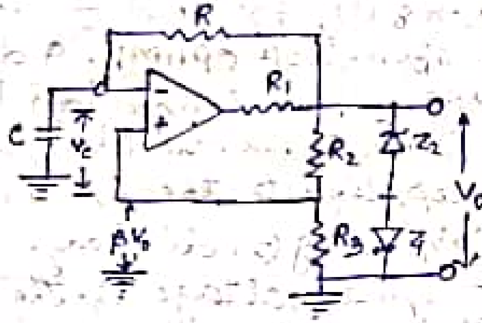

Fig (1)

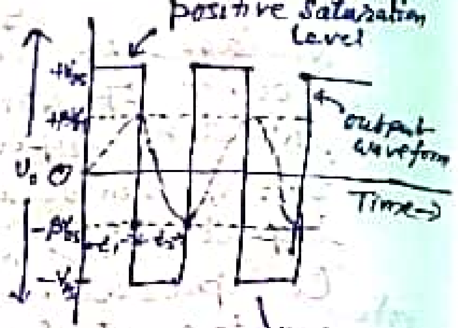

Fig (2)

This circuit switches respectively between these two state. The OP-AMP operates both positive and negative feedbacks ~~cont~~ and contains a timing capacitor C, at its inverting input terminals. The output voltage V_0 is limited by the break down voltage $+V_{os}$ and $-V_{os}$ of the two zener diodes Z_1 & Z_2 connected back to back across the output terminal of the OP-AMP. Thus V_0 will be either $+V_{os}$ or $-V_{os}$. A fraction of V_0 i.e $\beta = \frac{R_3}{R_2+R_3}$ is feedback to the non-inverting input. Thus in one state the amplifier output reaches a positive saturation level

$v_0 = +V_{os}$ (diode Z_2) and in the other state the amplifier output reaches a negative saturation level $V_0 = -V_{os}$ (diode Z_1). The output waveform is thus a square wave as shown in fig (2).

Expression For Frequency of The Oscillation :—

The input voltage v_i to the amplifier is.

$$v_i = v_c - \beta v_0 \quad \text{.....(1)}$$

when $v_i < 0$ i.e $v_c < \beta v_0$ or $v_c < \beta(+V_{os})$

or. $v_c < \beta V_{os}^{+}$ and therefore the capacitor C charges exponentially towards V_{os}^{+} through a time constant RC. The output remains constant at V_{os}^{+} until $v_c = +\beta V_{os}^{+}$ so that $v_i = v_0 - \beta V_{os}^{+} = 0$ 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

$$v_i = v_c - \beta v_0 = v_c + \beta V_{os}^{-} \longrightarrow (2)$$

$+V_{os} = V_{os}^{+}$ and $-V_{os} = V_{os}^{-}$

∴ The output ~~v_c~~ remains constant V_{os}^{-} until $v_c = -\beta V_{os}^{-}$ at which $v_i = 0$ and the reversal of state takes place. These waveforms are shown in fig (2)

Charging of 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 as the charging terminates at βV_{os}^+, the charging period, t_1, is given by

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

$$= RC \log \frac{V_{os}^+ - \beta V_{os}^-}{V_{os}^+ (1-\beta)} \longrightarrow (3)$$

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

$$t_2 = RC \log \frac{V_{os}^- - \beta V_{os}^+}{V_{os}^- (1-\beta)} \longrightarrow (4)$$

If $V_{os}^+ = V$ and $V_{os}^- = -V$ then $t_1 = t_2$ from eq (3) & (4) we get

so that the period of an oscillation or time period as

$$T = t_1 + t_2 = RC \log \frac{V+\beta V}{V(1-\beta)} + RC \log \frac{-V-\beta V}{-V(1-\beta)}$$

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

$$= RC \log \left\{ \left(\frac{1+\beta}{1-\beta}\right) \cdot \left(\frac{1+\beta}{1-\beta}\right) \right\}$$

$$= RC \log \left(\frac{1+\beta}{1-\beta}\right)^2$$

$$= 2RC \log \left(\frac{1+\beta}{1-\beta}\right) \longrightarrow (5)$$

$$= 2RC \log \left(\frac{R_2 + 2R_3}{R_2}\right)$$

$$= 2RC \log \left(1 + \frac{2R_3}{R_2}\right) \longrightarrow (5a)$$

$\because \beta = \frac{R_3}{R_2 + R_3}$

$\therefore 1+\beta = \frac{R_2 + 2R_3}{R_2 + R_3}$

$\& \; 1-\beta = \frac{R_2}{R_2 + R_3}$

This is the expression for time period of the oscillation. Now frequency of this oscillation is given by

$$f = \frac{1}{T} = \frac{1}{2RC \log \left(1 + \frac{2R_3}{R_2}\right)} \longrightarrow (6)$$

If $\frac{2R_3}{R_2} << 1 \therefore f = \frac{1}{2RC} \longrightarrow (7)$

from eqn (5), we conclude that time period is independent of saturation level V_{os}^+ and V_{os}^- and depends only on time constant RC and feedback factor β.

Use:— Astable multivibrator is very useful for fixed frequency oscillation in audio frequency range (10 c/s – 10 kc/s).