Astable Multivibrator (AMV)

**Aim**: To construct an astable multivibrator using transistors for getting square wave and to determine the frequency of oscillation.

**Apparatus**: Two n-p-n transistors, two fixed carbon resistors, two variable non-inductive resistors (pots), two capacitors, d.c. power supply, CRO and connecting terminals.

**Formula**:

\[ f = \frac{1}{T} = \frac{1}{0.69 (R_1 C_1 + R_2 C_2)} \text{ Hz} \]

OR

\[ f = \frac{1}{T} = \frac{1}{1.38 RC} \text{ Hz} \]

if \( R_1 = R_2 = R \) and \( C_1 = C_2 = C \)

**Description**: An astable or free running multivibrator is very important because it generates square waves of its own i.e., without any external excitation. It has no stable state but has only two quasistable (half stable) states between which it keeps on oscillating on its own accord.

![Fig. 1](image)

Fig. 1 shows the circuit of a symmetrical collector-coupled astable multivibrator using two identical transistors \( Q_1 \) and \( Q_2 \). It, in fact, consists of two common emitter \( RC \) coupled amplifier stages. The output of the first stage is coupled to the input of the second stage and the output of the second stage is coupled to the input of the first stage through \( R \) and \( C \).
The phase of a signal is reversed when it is amplified by a single stage of a CE amplifier. Hence after passing through two stages, it comes back to its original phase. Thus the signal fed back to the base of common emitter transistor is in the same phase as the original signal at its input. Thus a positive feedback takes place and circuit oscillates. The feedback is so strong that either the transistors are driven to saturation or to cut-off.

**THEORY :-** When power $V_{cc}$ is applied by closing switch S, collector current starts flowing in $Q_1$ and $Q_2$ and the coupling capacitors $C_1$ and $C_2$ start charging up. Since the characteristics of no two seemingly similar transistors can be exactly alike, one transistor, say $Q_1$ will conduct more rapidly than the other. Then the collector current of $Q_1$ will rise at a faster rate causing a decrease in its collector voltage. The resulting negative signal is applied to the base of $Q_2$ through $C_2$ and drives it towards cut-off. Consequently, the collector voltage of $Q_2$ (positive going signal) is fed to the base of transistor $Q_1$ through capacitor $C_1$. As a result of this positive going pulse, the collector current of $Q_1$ is further increased. The process being cumulative, in a short time, transistor $Q_1$ is saturated while $Q_2$ is cut-off. These actions are so rapid and instantaneous that $C_1$ does not get a chance to discharge. Under this situation, whole of $V_{cc}$ drops across $R_{L1}$ (since $Q_1$ is saturated or is in ON state) i.e., $V_{c1} = 0$ and point A is at ground (or zero) potential. Also, since $Q_2$ is cut-off (OFF state), there is no drop across $R_{L2}$ and point B is at $V_{cc}$.

Capacitor $C_2$ now begins to discharge through $R_2$, which decreases the reverse bias on base of transistor $Q_2$. Ultimately a forward bias is re-established at $Q_2$ which, therefore, begins to conduct. Consequently, Collector of $Q_2$ becomes less positive. This negative going voltage signal is applied to the base of transistor $Q_1$ through the capacitor $C_1$. As a result, $Q_1$ is pulled out of saturation and is soon driven to cut-off. Simultaneously $Q_2$ is driven to saturation. Now $V_{c2}$ decreases and becomes almost zero volt when $Q_2$ gets saturated. Consequently, potential of point B decreases from $V_{cc}$ to almost zero volt.

The transistor $Q_1$ remains cut-off and $Q_2$ in conduction until capacitor $C_1$ discharges through $R_1$, enough to decrease the reverse bias of $Q_1$. The whole of the cycle is repeated. The output of the multivibrator can be taken from the collector of either transistor. The output is a square wave, as shown in Fig. 2 with a peak amplitude equal to $V_{cc}$. 
**Switching Times**

It is seen that the multivibrator circuit alternates between a state in which $Q_1$ is ON and $Q_2$ is OFF and a state in which $Q_1$ is OFF and $Q_2$ is ON. The time for which either transistor remains ON or OFF is given by:

- ON time for $Q_2$ (or OFF time for $Q_1$) $T_1 = 0.69 R_1 C_1$
- ON time for $Q_1$ (or OFF time for $Q_2$) $T_2 = 0.69 R_2 C_2$

Hence, total time of the square wave $T = T_1 + T_2$

$$= 0.69 (R_1 C_1 + R_2 C_2)$$

If $R_1 = R_2 = R$ and $C_1 = C_2 = C$ i.e., the two stages are symmetrical, then

$$T = 0.69 (R C + R C) = 1.38 RC$$

**Frequency of Oscillation**: Frequency of the square wave is given by the reciprocal of the time period i.e.

$$f = \frac{1}{T} = \frac{1}{1.38 RC} \text{ Hz}$$

**Procedure**: The two transistors ($Q_1$ and $Q_2$) are connected in CE mode and they are given proper bias with the help of $R_{L1}$, $R_{L2}$ and $+V_{CC}$. Collector of each transistor is connected to the base of the other transistor through a condenser. The condensers $C_1$ and $C_2$ are connected to the power supply through the variable resistors $R_1$ and $R_2$. The collector of any one of the transistor is connected the Y-plates of CRO.

Switch on the power $V_{cc}$ and the power supply of CRO. Observe the square wave on the screen. Adjust the values $R_1$ and $R_2$ and the band switches of X and Y plates of CRO to get at least one complete wave on the screen.
Then the length of one complete wave (\(l\)) on screen is measured on horizontal scale, this is multiplied with the time base (\(t\)). The product will give the time period of the wave (\(l \times t = T\)). The reciprocal of ‘\(T\)’ gives the frequency (\(f\)). These values are noted in the table. This frequency is experimental frequency.

Now the Power \(V_{cc}\) is switched off and the resistance values of \(R_1\) and \(R_2\) are measured using multi-meter. The values \(R_1\), \(R_2\), \(C_1\) and \(C_2\) are also noted in the table. Substituting these values in the above formula we will get the frequency theoretically. The theoretical and experimental frequencies are compared. They are equal.

The experiment is repeated with different values of \(R_1\) and \(R_2\) (the values of \(C_1\) and \(C_2\) can also be changed, if possible).

**Precautions** :-
1. Select the two transistors such that they are identical.
2. Before going to the experiment the emitter, collector and base terminals of the two transistors should be identified properly.
3. The gain band switch of \(Y\) plates and band switch of time base are kept in proper position to observe at least one complete wave on the screen of CRO.

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<td>(C_1 = \mu F)</td>
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<td>S.N.o.</td>
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<td>(R_1 \Omega)</td>
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