INTRODUCTION

The basic circuit of a multivibrator consists of two transistors connected to form a feedback loop. There are three possibilities:

i) Bistable operation:- A bistable multivibrator has two stable states. The circuit remains in one of its stable state until a triggering signal causes a transition to the other stable state. A triggering signal is needed to initiate each transition.

ii) Monostable operation:- A monostable multivibrator has one stable state and one quasi-stable state. The circuit remains in its stable state until a triggering signal causes a transition to the quasi-stable state. Then after a certain time, determined by the values of the circuit constants, the circuit returns to its stable state. The process is repeated upon the application of each triggering signal.

iii) Astable operation:- An astable multivibrator has two quasi-stable states. The circuit alternates between the two quasi-stable states indefinitely. The time in each state depends upon the values of the circuit constants.

BISTABLE MULTIVIBRATOR

A common circuit of the bistable multivibrator is shown in Fig. 1. The bistable multivibrator has two input lines, S and R, and two outputs Q and \( \overline{Q} \) which provide complementary output signals. When the S-line (set-line) is energized, the logic level of output Q becomes “1” (V_{CE2} = V) and \( \overline{Q} \) becomes “0” (V_{CE1} = 0). When the R-line (reset-line) is energized, output Q becomes “0” (V_{CE2} = 0) and \( \overline{Q} \) becomes “1” (V_{CE1} = V). Thus a signal at the S-line sets output Q to the “1” state, and a signal at the R-line resets output Q to the “0” state.

The circuit works as follows. Assume that TR2 is saturated (Q = 0) and TR1 is cut off (\( \overline{Q} = 1 \)). When both the input signals are zero the logic “1” signal feed back to the base of TR2 from the collector of TR1 holds TR2 in
the saturated state. This ensures that the voltage at the collector of TR2 is practically zero, since both input signals to TR1 are zero, TR1 remains cut off and its output is logic “1”. This is one of the two stable operating conditions with Q = 0 and ̅Q = 1.

The application of a logic “1” signal to the S input line causes TR1 to saturate and its output voltage fall to zero. The input conditions of TR2 have now changed, both inputs being zero. This causes TR2 to be cut off, forcing its collector potential to rise to the logic “1” level. This is the second stable operating state of the circuit with Q = 1 and ̅Q = 0. The signal applied to the S-line can now be removed to zero, since the logic “1” signal fed back from output Q to the input of TR1 holds it in the stable state. The multivibrator can be resetted to its original state by application of a logic “1” signal to the reset input line of the circuit. The capacitors are used to improve the switching speed of the circuit; their function is to ensure that any change in voltage at the collector of one transistor is rapidly transmitted to the base of the other transistor.
a) Set up the circuit shown in Fig. 1.

b) With the power supplies on measure $V_{CE1}$, $V_{BE1}$, $V_{CE2}$ and $V_{BE2}$.

c) Apply 6 V (logic "1") to S. Measure the outputs at $\overline{Q}$ and Q. Apply +6 V to R. Observe and measure the voltage changes at the $\overline{Q}$ and Q outputs.

d) Connect the square wave generator to terminal S. Set the frequency to 400 Hz and slowly increase the voltage until a change of state is observed. Measure the amplitude of this applied voltage at which the multivibrator switches (Use an oscilloscope). Measure also the frequency and amplitude of the output at $\overline{Q}$.

e) Repeat (d) with the square wave connected to point R.

f) Compare your observations with expected results.

MONOSTABLE MULTIVIBRATOR

A common circuit of the monostable is shown in Fig. 2. Fig. 3 shows the waveforms at various points of the circuit when the multivibrator is triggered by a periodic signal. In the stable state transistor TR2 is saturated and TR1 cut off so that $V_{BE2}$ and $V_{CE2}$ are small and capacitor C is charged to V with polarity shown.

When a positive going pulse is applied to A the circuit is triggered into its quasi-stable state with TR1 driven into saturation and point P1 effectively grounded. Since P1 is grounded point P2 is at -V causing TR2 to be cut off. The capacitor C discharges through resistor R as the voltage across R is then 2 V. The voltage at P2 ($V_{BE2}$) thus rises from -V to V with a time constant RC. As $V_{BE2}$ approaches zero TR2 conducts and $V_{CE1}$ falls rapidly to zero. This fall in voltage is communicated to the base of TR1 by the feedback resistors $R_1$ and $R_2$ causing TR1 to cut off. The circuit then resumes its stable state.

The time interval during which the circuit is in its quasi-stable state is given approximately by

$$T = RC \ln 2 = 0.69RC$$
The waveform amplitudes are given by

\[ V_{BE2} = V \]
\[ V_{CE2} = \frac{R_1}{R_1 + R_C} V \]
\[ V_{BE1} = \frac{R_1}{R_1 + R_2} V' \]
\[ V_{CE1} = V \]

Fig. 2
a) Set up the circuit shown in Fig. 2.

b) With the power supplies switched on verify that the circuit is in its stable state by measuring $V_{CE1}$, $V_{BE1}$, $V_{CE2}$ and $V_{BE2}$.

c) Record these measurements.

d) Connect the square wave generator to input A. Set the frequency to 1 kHz and adjust the amplitude monitored at A until it is 2 V.

e) Monitor the voltage waveforms at the various points indicated in Fig. 2. Measure the amplitudes of these voltages by means of an oscilloscope and sketch their forms.

f) Monitor the voltage of $V_{CE1}$ on the oscilloscope and by adjusting the time base of the oscilloscope to a suitable range, measure the time interval $T$.

g) Compare your observations with expected results.

**ASTABLE MULTIVIBRATOR**

A common circuit of the astable multivibrator is shown in Fig. 4. When TR2 is saturated, the charge on $C_2$ causes TR1 to cut off until $V_{BE1}$ rises to zero, when TR1 saturates. The drop in potential at the collector of TR1 then causes TR2 to be cut off. The circuit will remain in this quasi-stable state until $V_{BE2}$ rises to zero when TR2 saturates. This process will carry on indefinitely and hence the circuit will flip from one quasi-stable state to the next in times given by the time constants $T_1$ and $T_2$.

\[
T_1 = 0.69R_2C_2
\]

\[
T_2 = 0.69R_1C_1
\]

The ratio $\frac{T_1}{T_2}$ is known as the mark-to-space ratio, and the frequency of oscillation is

\[
f = \frac{1}{T_1 + T_2}
\]
a) Connect up the circuit shown in Fig. 4.

b) Switch on the power supply. Monitor the voltage waveforms at the various points indicated in Fig. 4. Measure the amplitudes of these voltages and the time constants $T_1$ and $T_2$ by means of an oscilloscope. Sketch these voltage waveforms.

c) Remove the ends of $R_1$ and $R_2$ from the positive supply terminal and join these respectively to the two ends of a 2 kΩ potentiometer. Connect the wiper of the potentiometer to the positive supply terminal. With the power supply switched back on, observe how the mark-to-space ratio can be varied by turning the potentiometer wiper.

d) Compare your observations with the expected results.

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