Multivibrators

A MULTIVIBRATOR is an electronic circuit that generates square, rectangular, pulse waveforms, also called nonlinear oscillators or function generators.

Multivibrator is basically a two amplifier circuits arranged with regenerative feedback.

There are three types of Multivibrator:

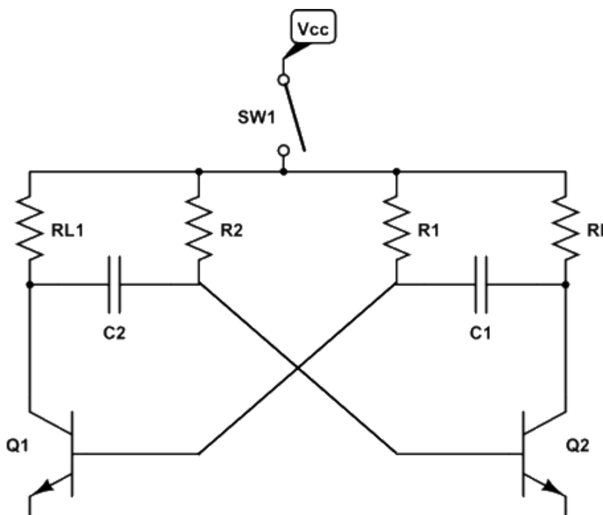
Astable Multivibrator: Circuit is not stable in either state—it continuously oscillates from one state to the other. (Application in Oscillators)

Monostable Multivibrator: One of the state is stable but the other is not. (Application in Timer)

Bistable Multivibrator: Circuit is stable in both the state and will remain in either state indefinitely. The circuit can be flipped from one state to the other by an external event or trigger. (Application in Flip flop)

Astable Multivibrator

Figure below shows the circuit of a collector coupled astable multivibrator using two identical NPN transistors Q_1 and Q_2. It is possible to have $R_{L1} = R_{L2} = R_L = R_1 = R_2 = R$ and $C_1 = C_2 = C$. In that case , the circuit is known as symmetrical astable multivibrator. The transistor Q_1 is forward biased by the V_{cc} supply through resistor R_2. Similarly the transistor Q_2 is forward biased by the V_{cc} supply through resistor R_1. The output of transistor Q_1 is coupled to the input of transistor Q_2 through the capacitor C_2. Similarly the output of transistor Q_2 is coupled to the input of transistor Q_1 through the capacitor C_1.



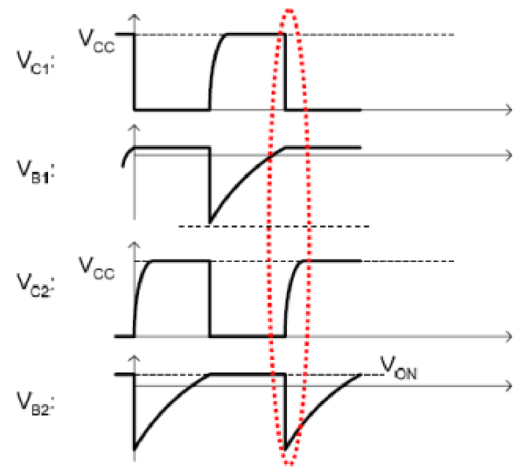


Figure (a)

It consists of two common emitter amplifying stages. Each stage provides a feedback through a capacitor at the input of the other. Because of capacitive coupling none of the transistor can remain permanently out-off or saturated, instead of circuit has two quasi-stable states (ON and OFF) and it makes periodic transition between these two states.

The output of an astable multivibrator is available at the collector terminal of the either transistors as shown in figure (a). However, the two outputs are 180^{o} out of phase with each other. Therefore one of the output is said to be the complement of the other.

Let us suppose that

1. When $Q_1$is ON, Q_2 is OFF and
2. When Q_2 is ON, Q_1 is OFF.

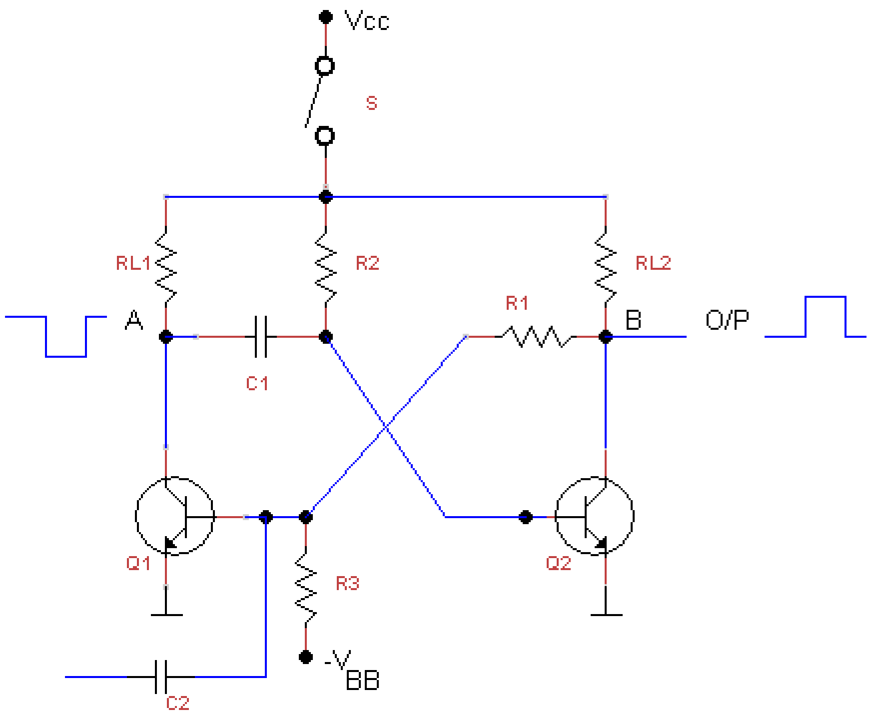
When the D.C power supply is switched ON by closing S, one of the transistors will start conducting before the other (or slightly faster then the other). it is so because characteristics of no two similar transistors can be exactly alike suppose that Q_1 starts conducting before Q_2 does. The feedback system is such that Q_1 will be very rapidly driven to saturation and Q_2 to cut-off. The circuit operation may be explained as follows.

1. Since Q_1 is in saturation whole of V_{CC} drops across R_{L1}. Hence $V_{C1} = 0$ and point A is at zero or ground potential.
2. Since Q_2 is in cut-off i.e. it conducts no current, there is no drop across R_{L2}. Hence point B is at V_{CC}.
3. Since A is at 0V C_2 starts to charge through R_2 towards V_{CC}.
4. When voltage across C_2 rises sufficiently (i.e. more than 0.7V), it biases Q_2 in the forward direction so that it starts conducting and is soon driven to saturation.
5. V_{CC} decreases and becomes almost zero when Q_2 gets saturated. The potential of point B decreases from V_{CC} to almost 0V. This potential decrease (negative swing) is applied to the base of Q_1 through C_1. Consequently, Q_1 is pulled out of saturation and is soon driven to cut-off.
6. Since, now point B is at 0V, C_1 starts charging through R_1 towards the target voltage V_{CC}.
7. When voltage of C_1 increases sufficiently. Q_1 becomes forward-biased and starts conducting. In this way the whole cycle is repeated.

It is observed that the circuit alternates between a state in which Q_1 is ON and Q_2 is OFF and the state in which Q_1 is OFF and Q_2 is ON. This time in each states depends on RC values. Since each transistor is driven alternately into saturation and cut-off. The voltage waveform at either collector (points A and B in figure (b)) is essentially a square waveform with a peak amplitude equal to V_{CC}.

Monostable multivibrator

Figure shows the circuit of a monostable multivibrator using NPN transistor. It consists of two similar transistor Q_1 and Q_2 with equal collector loads i.e. $R_{L1} = R_{L2}$ the values of $-V_{BB}$ and R_3 are such as to reverse bias Q_1 and keep it at cut off. The collector supply V_{cc} and R_2 forward bias Q_2 and keep it at saturation. A trigger pulse is given through C_2 to obtain the square wave.



Initial Conditions:

Let us suppose that in the absense of a trigger pulse and with S closed, initially the circuit is in its stable state i.e. Q_1 is OFF (at cut-off) and Q_2 is ON (at saturation).

When Trigger Pulse is applied

Let us see as what happens when the trigger is applied.

1. If positive trigger pulse is off sufficient amplitude, it will override the reverse bias of the E/B junction of Q_1 and give it a forward bias, Hence Q_1 will start conducting.
2. As Q_1 conducts, its collector voltage falls due to voltage drop across R_{L1}. It means that potential of point A falls (negative going signal). This negative going voltage is fed to Q_2 VIA C_1 where it decreases its forward bias.

3. As collector current of Q_2 start decreasing, potential of point B increases (positive going signal) due to lesser drop over R_{L2}. Soon, Q_2 comes out of conduction.
4. The positive going signal at B is fed VIA R_1 to the base of Q_1 where it increases its forward bias further. As Q_1 conductors more potential of point A approaches 0V.
5. This action is cumulative and ends with Q_1 conducting at saturation and Q_2 cut-off.

Return to initial Stable State:

1. As point A is at almost OV, C_1 starts to charge through saturated Q_1 to ground.
2. As C_1 charges, the negative potential at the base of Q_2 is decrease. As C_1 charges further Q_2 is pulled out of cut-off.
3. As Q_2 conducts further, a negative going signal from point B VIA R_1 drives Q_1 into cut-off.

Hence, the circuit reverts to its original state with Q_2 conducting at saturation and Q_1 cur-off. It remains in this state till another trigger pulse comes along when the entire cycle repeats itself.

The width of duration of the pulse obtained at the collector or output of either transistor (Q_1 or Q_2) of the monostable multivibrator is given by the expression

$T = 0.69\ R_2\ C_1$

BISTABLE MULTIVIBRATOR

The bistable multivibrator has two absolutely stable states. It will remain in whichever state it happens to be until a trigger pulse causes it to switch to the other state. For instance, suppose at any particular instant, transistor Q_1 is conducting and transistor Q_2 is at cut-off. If left to itself, the bistable multivibrator will stay in this position for ever. However, if an external pulse is applied to the circuit in such a way that Q_1 is cut-off and Q_2 is turned on, the circuit will stay in the new position. Another trigger pulse is then required to switch the circuit back to its original state.

In other words a multivibrator which has both the state stable is called a bistable multivibrator. It is also called flip-flop, trigger circuit or binary. The output pulse is obtained when, and why a driving (triggering) pulse is applied to the input. A full cycle of output is produced for every two triggering pulses of correct polarity and amplitude.

Figure (a) shows the circuit of a bistable multivibrator using two NPN transistors. Here the output of a transistor Q_2 is coupled to the input of a transistor Q_1 through a resistor R_2. Similarly, the output of a transistor Q_1 is coupled to the base of transistor Q_2 through a resistor R_1. The base resistors (R_3 and R_4) of both the transistors are connected to a common source ($-V_{BB}$). The output of a bistable multivibrator is available at the collector terminal of the both the transistor Q_1 and Q_2. However, the two outputs are the complements of each other.

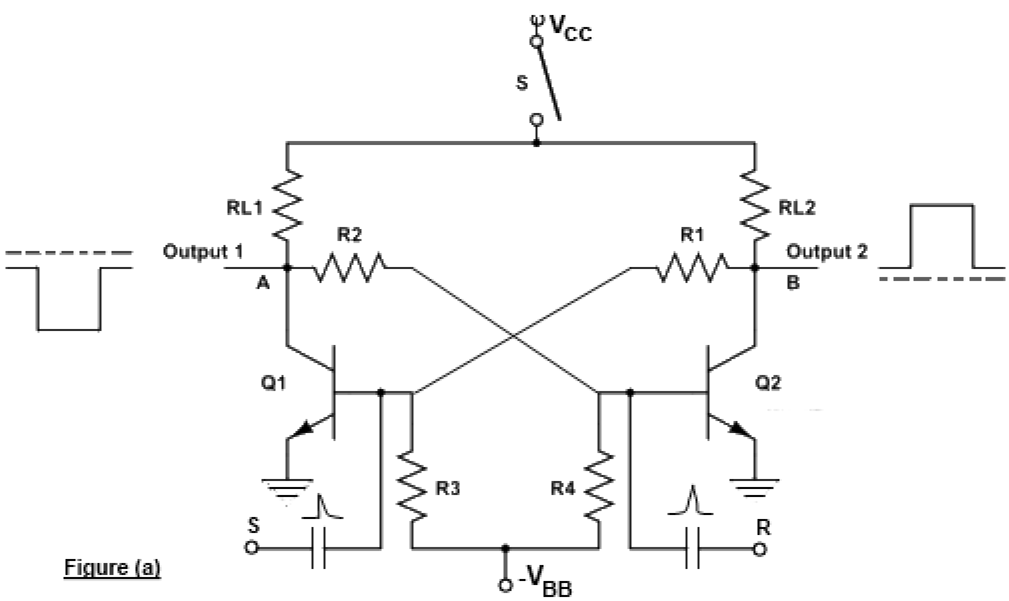


Figure (a)

Let us suppose, if Q_1 is conducting, then the fact that point A is at nearly ON makes the base of Q_2 negative (by the potential divider R_2 - R_4) and holds Q_2 off.

Similarly with Q_2 OFF, the potential divider from V_{CC} to $-V_{BB}$ (R_{L2}, R_1, R_3) is designed to keep base of Q_1 at about 0.7V ensuring that Q_1 conducts. It is seen that Q_1 holds Q_2 OFF and Q_2 hold Q_1 ON.

Suppose, now a positive pulse is applied momentarily to R. It will cause Q_2 to conduct. As collector of Q_2 falls to zero, it cuts Q_1 OFF and consequently, the BMV switches over to its other state.

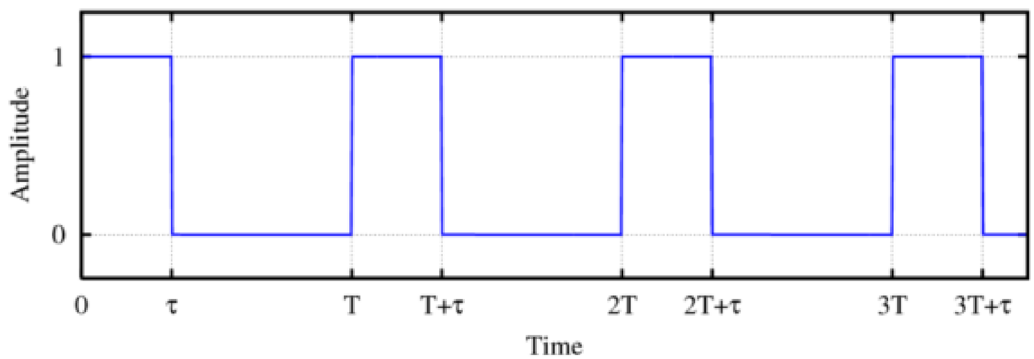
Similarly, a positive trigger pulse applied to S will switch the BMV back to its original state.

Uses:

1. In timing circuits as frequency divider
2. In counting circuits
3. In computer memory circuits

Some Important terms

Duty Cycle duty cycle is defined as the ratio of pulse duration to pulse period.



The pulse duration is τ; this is how long the pulse remains high (amplitude=1 in the figure).The pulse period is T ; this is the duration of one complete cycle, and is just the inverse of the frequency in Hz (*f = 1/T).*

$$D = \tau / T$$